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# MOTHZV-2: A COMPUTER SIMULATION OF *HELIOTHIS ZEA* AND *HELIOTHIS VIRESCENS* POPULATION DYNAMICS

## Users Manual

By A. W. Hartstack, Jr., J. A. Witz, J. P. Hollingsworth, R. L. Ridgway, and J. D. Lopez<sup>1</sup>

### ABSTRACT

Consisting of a main program and 16 subroutines, MOTHZV-2 simulates the population dynamics of *Heliothis zea* (Boddie) and *Heliothis virescens* (F.) from egg to adult. The input includes measurable and reported factors influencing population development, such as crop phenology, temperature, moonlight, migration, predation, parasitism, oviposition, and cannibalism. The model accurately predicted field population of *Heliothis* eggs, larvae, and adults. The complete computer program and example input and output data are given. **KEY WORDS:** computer-simulated *Heliothis* populations, *Heliothis virescens*, *Heliothis zea*, insect population dynamics, insect population forecasting, MOTHZV-2.

### INTRODUCTION

MOTHZV-2 is a computer simulation of the population dynamics of *Heliothis zea* (Boddie) and *Heliothis virescens* (F.). It is based on MOTHZ-1 (5) and MOTHZ-2<sup>2</sup> but incorporates considerably more detailed population and physiological algorithms. Stinner et al. (22) described a somewhat similar *Heliothis* model; however, they did not include the details of various biological phenomena affecting population dynamics. Most of the basic factors, e.g.,

mortality, parasitism, and crop phenology, were entered in the context of the input data. Their model did, however, include a spatial grid of crop types so that movement of the population could be studied.

MOTHZV-2 consists of a main program and 16 subroutines. Simulation begins with input of either eggs or moths and can be carried through as many generations as occur during one season. No provisions are included for simulating moths entering or emerging from diapause. A bookkeeping system is used so that the numbers of eggs, first- to third-instar larvae, fourth- and fifth-instar larvae, pupae, preovipositing adults, and ovipositing adults can be recorded for each day of simulation. Printouts of all input as well as other calculated parameters are made along with daily population of simulated insects. Graphs of life tables are optional.

We describe the model in the order of the insects' life cycle events. The model can be used to simulate either *H. zea* or *H. virescens* or both

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<sup>2</sup> Hartstack, A. W., Jr. Model of *Heliothis zea*. 1973 Annual Report of the Cotton Insects Research Laboratory, College Station, Tex. 77840, 158 pp.

simultaneously. If in the following discussion no reference to species is made, both species are treated alike. Many biological factors other than those in the model affect *Heliothis* populations, but at this time these parameters are assumed to be constants or are neglected completely. Also, in some cases, more information is needed on the assumptions made in the model to enhance accurate prediction.

The program is written in FORTRAN and has been run on IBM 370 and AMDAHL 470 computers. It is stored on disk in compiled form at Texas A&M University Computer Center.

## DESCRIPTION OF MODEL

### Rate of Egg Production

Temperature has been shown to influence the number of eggs a moth lays, but research results have not been consistent (2, 8, 17). In general, maximum egg production is attained between 22.2° and 25.5° C and is reduced to nearly zero at 12.8° and 35° C. Figure 1 (G9) shows the relation between oviposition rate and temperature as described by

$$X = |75 - \text{EGLYTM}| \quad (1)$$

$$\text{and } P_1 = 1.1 - 0.05146X, \quad (2)$$

where EGLYTM=average temperature (°F) during the 3-hour period after sunset (fig. 1:G7),

and  $P_1$ =probability of oviposition (assumed to be 1.0 between 22.2° and 25.5° C).

Quaintance and Brues (21) and Phillips and Whitcomb (18) found that most eggs were laid in early evening. However, no data are available to predict what happens if temperature inhibits oviposition early in the evening but becomes ideal later or during the day. McColloch (19) stated that oviposition normally occurs at night but that it may occur during the daytime on cloudy or cool days. Accordingly, the 3 hours after sunset were assumed to be the oviposition period.

Moth age has been shown to affect fecundity (2, 8, 17, 21). Isely (8) and Quaintance and Brues (21) also found an interaction between age and temperature in which longevity and reproductive potential were greater at cooler

temperatures (21.6°–26.7° C). Higher temperatures increased daily production of eggs but shortened the oviposition period, thereby reducing the overall reproductive potential. Figure 2 shows the oviposition period of *Heliothis* moths calculated for two temperatures. A function such as the gamma might fit these data; however, we used a linear approximation by fitting straight-line segments through the points determined by<sup>3</sup>

$$\text{TRUN}_i = \left( \sum_{j=i-\text{AGE}}^i \text{TEMAVG}_j \right) / \text{AGE}, \quad (3)$$

$$\text{PREOVI} = (5,330) (\text{TEMAVG}_i^{-1.32}) + 0.6, \quad (4)$$

$$\text{IPEAK} = (3,030,000) (\text{TRUN}_i^{-3.11}), \quad (5)$$

$$\text{ITOP} = (240,000) (\text{TRUN}_i^{-2.01}), \quad (6)$$

$$\text{and } \text{IEND} = (911,000) (\text{TRUN}_i^{-2.53}), \quad (7)$$

where  $\text{TRUN}_i$ =average temperature during moth's adult life on day  $i$ =AGE,

$\text{TEMAVG}_i$ =average temperature for  $i$ th day of moth's life (°F),

AGE=age of moth on day of simulation,

PREOVI=length of preoviposition period (rounded to nearest whole day),

IPEAK=age (rounded to nearest whole day) when *Heliothis* moth attains maximum reproductive potential,

ITOP=number of days (rounded to the nearest whole day) a moth remains at maximum reproductive potential,

and IEND=age at which a moth no longer oviposits.

When the above events are calculated, a linear relationship between them is assumed, so egg production potential ( $P_2$ ) can be readily calculated.

<sup>3</sup> Some of the terms used in the equations in the model description section of this paper may be slightly different in spelling or meaning from the terms used in the computer program. This was done to simplify explanation of what the simulation model accomplishes rather than how it is accomplished.

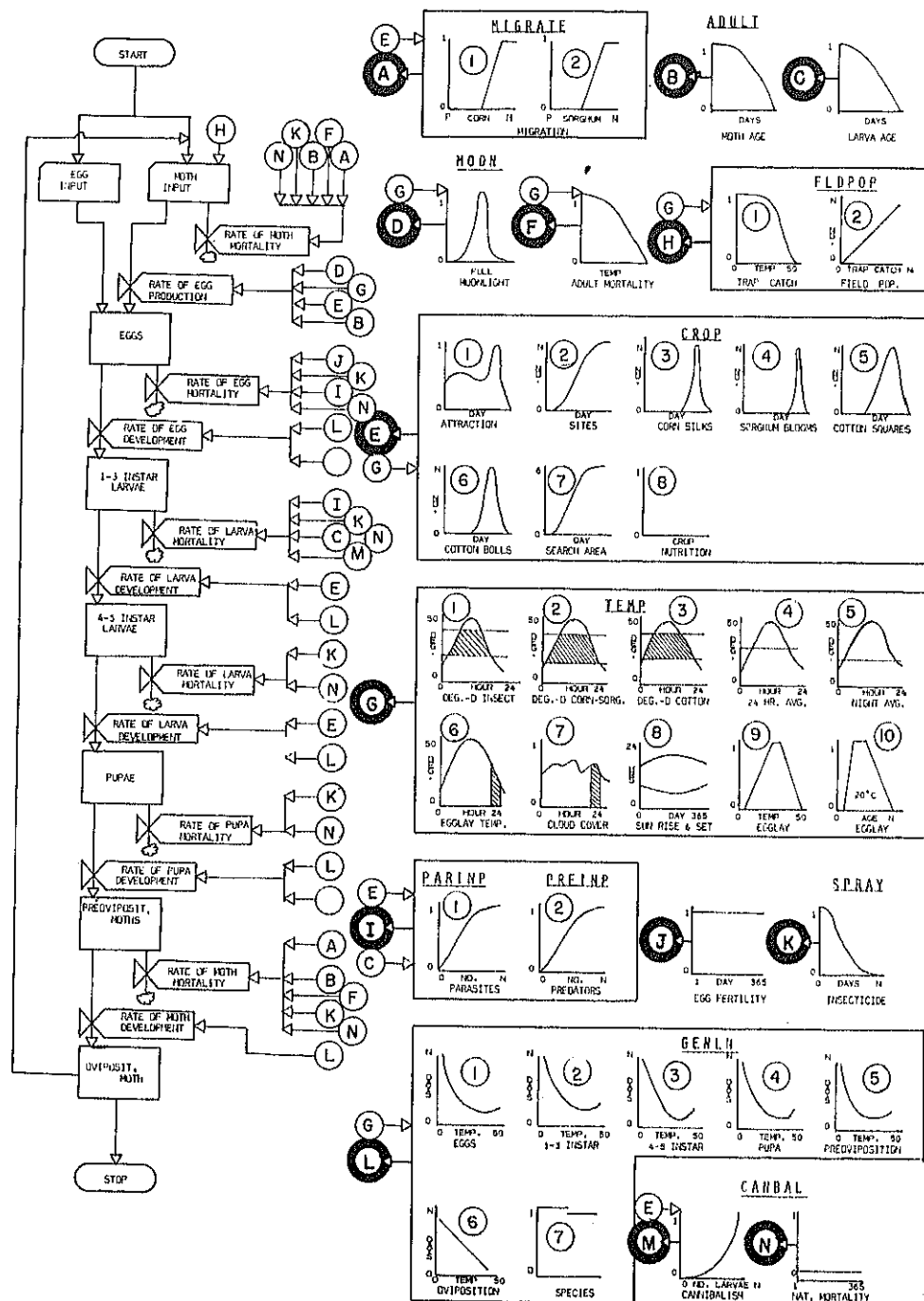


FIGURE 1.—Flow diagram of MOTHZV-2.

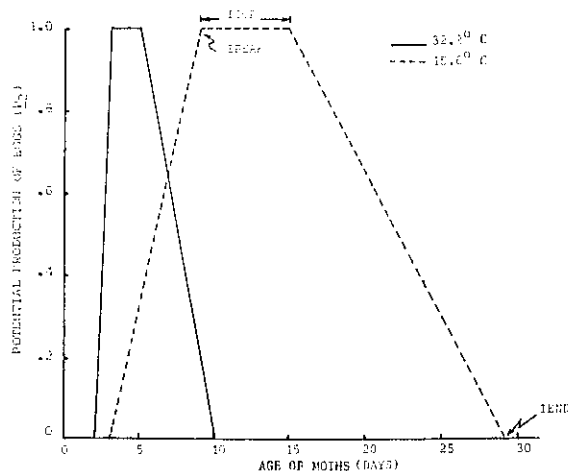


FIGURE 2.—The interaction of age and average daily temperature on reproduction potential of *Heliothis* moths.

Researchers have shown that phenological phenomena (e.g., silking date) have a significant influence on the probability of *Heliothis* moths' being attracted to a crop and ovipositing (3, 6, 8, 13, 19). This influence makes a crop submodel necessary. A corn model developed by Curry (1) was adapted to generate the needed corn phenology (fig. 1: E—1-3, 7, 8). (The probable attraction of corn,  $P_3$ , to *H. virescens* is assumed to be zero, since corn is not a reported host of this insect.) A simple sorghum model and a portion of SIMCOT II (14), a cotton model, were also adapted (fig. 1: E—1, 2, 4-8).

Nemec (15, 16) reported reduced oviposition by *Heliothis* moths during periods of full moon and during simulated moonlight. Oviposition was inhibited 3 or 4 days before full moon but was resumed 1 or 2 days after full moon and usually peaked 3 or 4 days after full moon. Hartstack's data (6) showed a significant reduction in rates of *Heliothis* population increase during moonlight periods. Consequently, if one assumes that maximum egg laying is from 2030 to 2330 hours (approximately, the 3-hour period after sunset), the relative amount of moonlight during that period can be calculated (fig. 3). Since the moon rises about 1 hour later each night, the 2030-2330 period has considerably more moonlight before full moon than after. The probability of maximum oviposition ( $P_4$ ) in relation to moonlight is stored as a data array and used in the simulation as needed. The probability is increased (not >1.0) for cloud cover (e.g., if cloud cover is 50%, the effect of moonlight is reduced by 50%).

The egg-laying probability (EGLYPR) for a particular day is calculated by multiplying the four probability factors together:

$$\text{EGLYPR} = (P_1) (P_2) (P_3) (P_4). \quad (8)$$

The total number of eggs laid per moth per day (TOLEGG) is calculated by

$$\text{TOLEGG} = (\text{EGLYPR}) (\text{EGPEMT}), \quad (9)$$

where EGPEMT = maximum number of eggs a *Heliothis* moth could lay per day if all factors were ideal.

EGPEMT is assumed to be 300 and 400, respectively, for *H. zea* and *H. virescens* and would result in maximum lifetime laying of 2,000 to 3,000 eggs per moth (8, 21).

### Egg Mortality

There are many probable causes of egg infertility (e.g., temperature, population density, number of matings, and age). MOTHZV-2 uses a constant fertility rate of 90% (fig. 1: J). The model does not remove infertile eggs from the egg population until they should have hatched.

Parasites, specifically *Trichogramma* spp., are an important cause of egg mortality (11, 13). Detailed quantitative models for the population dynamics of various egg parasites have

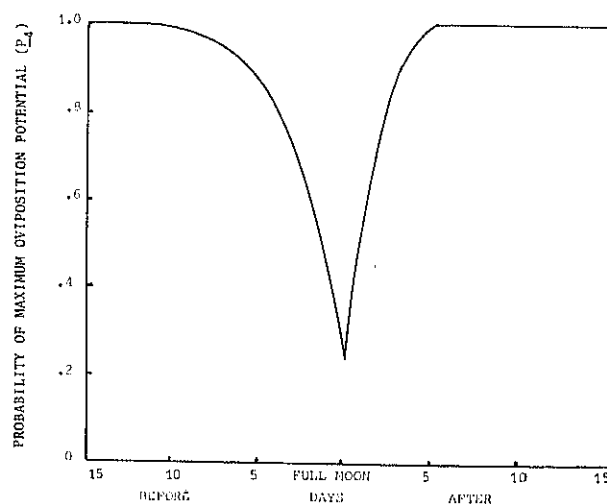


FIGURE 3.—The probability of maximum oviposition as related to the relative intensity and phase of moonlight during the 3-hour period after sunset.

not been constructed at this time; therefore, estimates must be used (fig. 1: 1—2). Four options are available:

*Option 1.*—Enter number of parasites. Knippling and McGuire (10) presented an empirical population model of parasites based on the following assumptions: (a) 5,000 *Trichogramma* per acre would find 50% of the host eggs. (b) 10,000 *Trichogramma* per acre would search the same plant area twice. However, since searching is random, the additional 5,000 parasites would search one-half the area previously searched and one-half the unsearched area, thus leaving one-fourth the area unsearched. (c) The searching capability of *Trichogramma* and its efficiency in parasitizing host eggs are assumed to be completely independent of host egg density. These assumptions were based on a search area factor (SAREA) of 1.0, which is assumed to occur when the crop becomes attractive (6- to 12-inch height for corn) and to increase to about 6.0 at crop maturity. Equation 10 is Knippling and McGuire's model.

$$PTRICH = 1 - \exp \left( \frac{(-0.693) (TRICH)}{(N) (SAREA)} \right), \quad (10)$$

where PTRICH=probability of parasitism by *Trichogramma*,

TRICH=number of parasites,

N=number of parasites required to obtain 50% parasitism,

and SAREA=relative search area.

N is assumed to be 5,000 (as postulated by Knippling and McGuire) for native egg parasites. N was calculated to be 45,000 for reared *Trichogramma* (specifically, for those reared at Agricultural Research Service's Cotton Insects Research Laboratory, College Station, Tex.). The number of parasites must be read in for each day of simulation. Figure 4 shows typical parasitism curves calculated by the model.

*Option 2.*—Enter daily percentage of parasitism. If the number of parasites is not available, an estimated daily percentage of parasitism can be read in.

*Option 3.*—Enter maximum daily rate of parasitism. The maximum daily rate of parasitism is assumed to occur in corn during the peak silking period (90%–95% silks present),

when many eggs are present. From the egg parasitism percentage the model generates an egg parasitism curve starting from the day when the crop becomes attractive; figure 5 shows the curve for corn. Parasitized eggs are not removed from the egg population by the model until after the parasites would have emerged, since field counts of eggs may include parasitized eggs. A running total of parasitized eggs is kept so that the apparent field parasitism can be calculated for each day for comparison with field data for verification.

*Option 4.*—Enter number of *Trichogramma*. The rate of parasitism by *Trichogramma* is calculated as a function of the number and the age of adult *Trichogramma* and of environ-

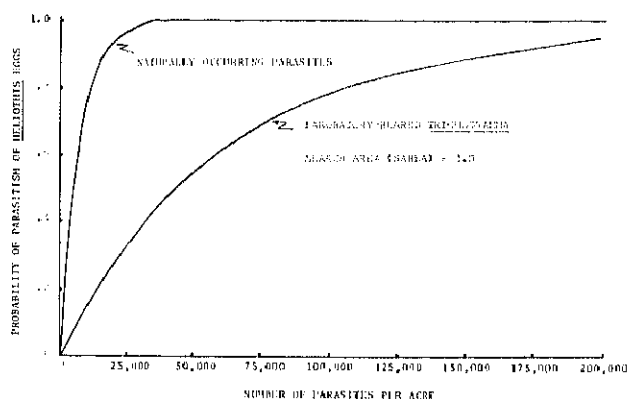


FIGURE 4.—Typical egg parasitism curves generated by model.

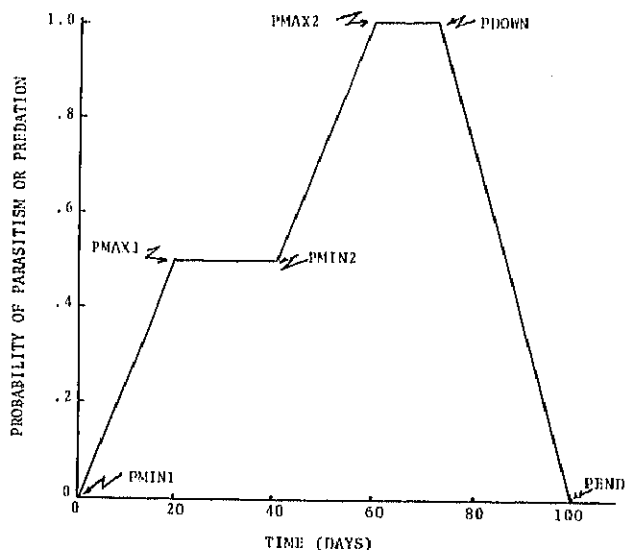


FIGURE 5.—Parasitism or predation curve generated for corn (option 3).



mental temperature. The potential population of *Trichogramma* emerging from parasitized *Heliothis* eggs is calculated and can be used to predict parasitism rates once the population of *Trichogramma* has been initialized.

Egg predators are handled like parasites. Knipling and McGuire's (10) model, equation 10, was adapted for egg predators. The value of  $N$  is assumed to be 14,500 and 45,000 for native egg predators and laboratory-reared *Chrysopa*, respectively (determined from field data by the Cotton Insects Research Laboratory). Field counts of predators are obtainable and can be used in the model. Egg predators have been placed by the Cotton Insects Research Laboratory into seven groups. The number of predators in each group can be adjusted by a relative efficiency factor, which can be estimated from intuitive and factual knowledge of the predators. The predator groups are *Scymnus*, other Coccinellidae, other Coleoptera, *Orius*, *Geocoris*, other Hemiptera, and *Chrysopa* immatures.

The daily percentage of predation can be used if the number of predators is not available. Also, as described for parasites, the maximum daily rate of predation can be used, and the model will generate daily rates.

The model provides for a daily input of mortality from ovicides for each species. A constant 4.5% daily rate is assumed for mortalities caused by other agents.

### Rate of Egg Development

Researchers have shown that temperature is the major factor regulating the rate of development of *Heliothis* under normal conditions (2, 6, 8, 12, 21). Development ceases at temperatures below 12.6° C and is interrupted at temperatures above 33.3° C (fig. 1: G—1).

The 484.9 degree-days required for a complete life cycle of *Heliothis* (6) was divided into stages (e.g., eggs and small larvae). It was determined that 40.5 degree-days between 12.6° and 33.3° C were required for development and hatching of eggs. Degree-days above 33.3° C are subtracted from the sum. Figure 6 shows the development time in days required for various temperatures. Hartstack (6) and Fye and McAda (2) reported a slightly longer time for *H. virescens* than for *H. zea*; therefore, the model is written so that a percentage of reduction or increase can be used.

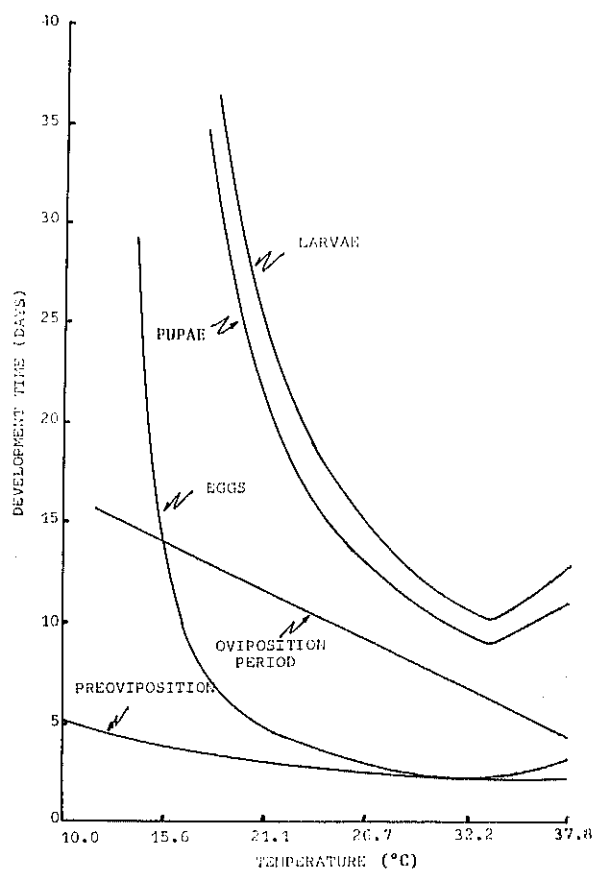


FIGURE 6.—Development time as a function of temperature for *Heliothis* eggs, larvae, pupae, and adults.

### Larval Mortality

Knipling (9) developed a population model for larval parasites that is, in principle, identical to the *Trichogramma* model discussed earlier. The value of  $N$  for larval parasites was assumed to be 300, as suggested by Knipling. Parasitism is applied only to small larvae (first- to third-instar). If numbers of parasites are not available, the daily percentage of parasitism or the maximum daily rate can be used for small larvae. The larval parasitism pattern is calculated exactly as described for egg parasitism (shown in fig. 5).

Knipling and McGuire's (10) model, equation 10, was also adapted for predators of small larvae. The value of  $N$  was assumed to be 9,000 and 13,000 for native and laboratory-reared *Chrysopa* immatures, respectively (determined from field data by the Cotton Insects Research Laboratory). The daily rate of predation calcu-

lated by equation 10 is reduced in relation to the age of the larvae, as follows:

$$\text{PREDOR}' = (\text{PREDOR}) \exp \left( \frac{(-0.42)(\text{AGE})}{0.657} \right), \quad (11)$$

where  $\text{PREDOR}'$  = percentage of predation after adjustment for age of larvae,

$\text{PREDOR}$  = percentage of predation calculated by equation 10,

and  $\text{AGE}$  = age of larvae in days.

Larval predators are grouped by the Cotton Insects Research Laboratory into the same groups listed for egg predators. The larval predator numbers are adjusted by estimated relative efficiency factors. Daily percentage of predation of small larvae can be read in if the number of predators is not available. The daily percentage is reduced for age of larvae by equation 11. If the maximum daily rate of predation of small larvae is used, the larval predation pattern is calculated as was described for egg predation (shown in fig. 5), and again the daily percentage is reduced for age of larvae by equation 11.

Mortality of larvae by cannibalism is considered for *H. zea* only (fig. 1: M). Subroutine CROP calculates the number of "sites" available daily for egg laying. Pieters and Sterling (20) reported that *H. zea* eggs are distributed in the field as described by the negative binomial and that the dispersion factor (DF) of the negative binomial for *H. zea* eggs in cotton is 0.36. Cannibalism of *H. zea* is considered by many to be negligible in cotton but very high in corn, since *H. zea* eggs are concentrated on silks when these sites are available. A dispersion factor of 0.36 is assumed here for corn. The number of sites available is assumed to be the number of plants times the relative search area (SAREA) until silks appear. At that time the number of sites is reduced to the number of silks available, since most eggs are laid on silks when they are available. It is assumed that when silks become 15 days old they are dry and no longer attractive for oviposition. It is also assumed that a larvae reaches the fourth instar before it becomes cannibalistic and destroys all smaller larvae on the same site. Only a small

percentage of small larvae will be destroyed in 1 day, but this percentage will increase as the larvae develop and are more active. The number of surviving larvae is determined by

$$\text{PRBLAR}_i = \text{TOTALS}_i \div \text{SITES}_i, \quad (12)$$

$$\text{ATE}_i = 0.05 + 0.05(\text{AGE}_i), \quad (13)$$

and

$$\text{POP}'_i = \text{POP}_i - (\text{POP}_i)(\text{PRBLAR}_i)(\text{ATE}_i), \quad (14)$$

where  $\text{PRBLAR}_i$  = probability of a large *H. zea* larva being on a site on day *i*,

$\text{TOTALS}_i$  = number of surviving large *H. zea* larvae on day *i*,

$\text{SITES}_i$  = number of sites available for oviposition on day *j* (day *j* is the day when the eggs that are being advanced through the simulation were laid),

$\text{ATE}_i$  = percentage of small *H. zea* larvae cannibalized on sites with a large larvae on day *i*.

$\text{POP}_i$  = the number of small *H. zea* larvae surviving on day *i* from eggs laid on day *j*,

and

$\text{POP}'_i$  = the small *H. zea* larvae surviving cannibalism until the next day.

This calculation is done each day until the surviving small larvae laid on day *j* become large larvae. On the last day of the third instar the probability of more than one surviving small larva being on the same site is calculated, and the population is reduced to one per site by solving

$$\text{XBAR}_i = \text{POP}_i \div \text{SITES}_i, \quad (15)$$

$$\text{PRBNEW}_i = 1 - \left( \frac{\text{DF}}{\text{DF} + \text{XBAR}_i} \right)^{\text{DF}}, \quad (16)$$

$$\text{and } \text{POP}'_i = (\text{SITES}_i)(\text{PRBNEW}_i), \quad (17)$$

where  $\text{XBAR}_i$  = number of surviving small *H. zea* larvae per site on day *i*,

$\text{PRBNEW}_i$  = probability that one or more small larvae are on a site on day *j*,

and  $DF = \text{dispersion factor of the negative binomial (0.36)}$ .

The model provides for separate inputs of mortalities of small and large larvae from insecticides. A constant daily rate of 4.0% is assumed for mortalities from natural causes.

### Rate of Larval Development

Degree-day figures used for the average development of small larvae (one- to three-instar) and large larvae (four- or five-instar) are 81.7 and 120.6, respectively, calculated as for eggs. Isely (8) reported different development times for *H. zea* larvae held at constant temperatures when they were fed various crops and crop parts. Corn ears were apparently the most nutritious, since larval development was significantly faster with this diet. Our unpublished field data at College Station support these results, and this factor has been included in the model. The nutrition factor used for corn plants and for cotton plants and fruit is 1.0. If larvae are developing on corn plants when ears are present, 0.65 is used. The nutrition factor for larvae developing on sorghum is 1.1.

### Pupal Mortality

The only mortality inputs for pupae are a constant natural mortality of 3.0% per day. Mortalities from insecticides can also be used.

### Rate of Pupal Development

Pupae require 123.9 degree-days for development. Figure 6 shows this temperature-time relationship.

### Adult Mortality

Fye and McAda (2) and Sterling<sup>1</sup> reported a temperature survival relationship for *Heliothis* moths. Figure 7 shows the probability of survival of adult moths as related to age and temperature. The following equations were developed to describe this survival probability:

$$FACTK = 1.2919 + (0.02724) (TEMAVG), \quad (18)$$

<sup>1</sup> Winfield L. Sterling, personal communication.

and  $SURV = 1.0 - 1.7724$

$$\exp\left(\frac{-11.4457}{(FACTK)(L)}\right), \quad (19)$$

where  $FACTK = \text{temperature constant for exponential equation,}$

$TEMAVG = \text{average air temperature (°F) on day of simulation,}$

$SURV = \text{probability of survival to L age,}$

and  $L = \text{age of moth in days.}$

Survival of moths at temperatures below 20° C is assumed to be the same as at 20° C. Daily mortalities from insecticides can be used for adult moths of both species. Snow et al. (24) reported that few moths lived beyond the sixth night after their emergence in the field. To simulate this high mortality, we used a daily rate of 15.0% for mortalities from natural causes.

### Migration

Crop phenological data are used to calculate emigration from corn and sorghum. In corn and sorghum the mature date (IM) is used to start the emigration, which builds to a maximum at the dry date (ID) and then remains constant for the rest of the simulation. The maximum percentage of emigration is read in. These moths are stored and can be used later as immigrants to other crops.

### Duration of Oviposition

Fye and McAda (2) and Isely (8) showed

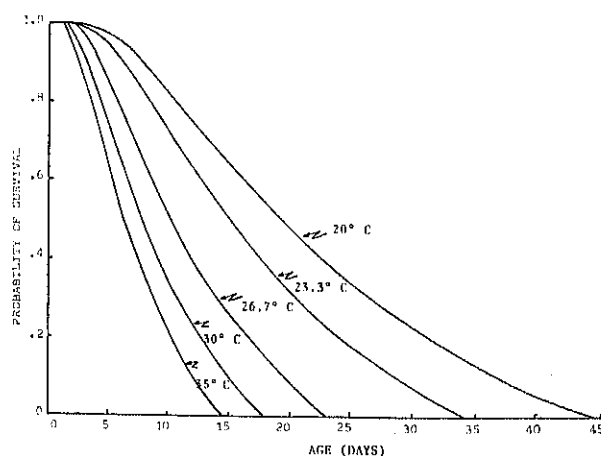


FIGURE 7.—Probability of *Heliothis* moth survival as related to age and temperature.

that the duration of oviposition is a function of temperature. We used the following equation to estimate the duration and to terminate it:

$$\text{IGENZV6} = 28.25 - (0.24037) (\text{TEMAVG}), \quad (20)$$

where IGENZV6=length of oviposition period,

and TEMAVG=average air temperature (°F) on day of simulation.

## DESCRIPTION OF SUBROUTINES

### Temperature (TEMP)

All temperature and cloud-cover input and the calculation of degree-days are handled by TEMP (fig. 1: G). There are two options for putting daily temperature in: (1) hourly temperature and (2) daily maximum and minimum temperatures. The hourly temperature takes precedence if the data are available. When maximum and minimum temperatures are used, hourly temperatures are estimated by assuming a cosine-wave fluctuation between maximum and minimum readings at 1400 and 0200 hours, respectively.

TEMP calculates the degree-days for corn as well as for *Heliothis*. For example, the degree-days for *Heliothis* are calculated by

$$\text{ED}_a = \sum_{X=1}^{24} (T_X - 12.6) - 2(T_X - 33.3) \quad (21)$$

$$\text{and } \text{ED}_a' = \text{ED}_a + \text{ED}_{a-1} + \dots + \text{ED}_{a-n}, \quad (22)$$

where  $\text{ED}_a$ =degree-days on day  $a$ ,

$X$ =hour,

$T_X$ =hourly temperature on day  $a$  (°C),

$\text{ED}_a'$ =accumulated degree-days from day  $n$  to day  $a$ , imposing only positive values of  $(T_X - 12.6)$  and  $(T_X - 33.3)$  be summed,

and  $n$ =day number of start of simulation (Julian).

Multiplying  $(T_X - 33.3)$  by 2 causes a reduction in degree-days for temperatures above 33.3° C, thereby simulating the retardation of

the development of *Heliothis* by high temperatures. Also calculated in TEMP are the accumulated degree-days for corn, sorghum, and cotton, the average daily temperature, the average nightly temperature, the average temperature for the 3 hours after sunset (oviposition temperature), the time of sunrise and sunset, and the percentage of cloud cover during the oviposition period.

### Generation Length (GENLN)

The degree-days calculated in TEMP are used to calculate the number of days required for development of the *Heliothis* (fig. 1: L). The following equation illustrates the GENLN function:

$$D_c = \text{ED}'_{a+n} - \text{ED}'_a > 40.5, \quad (23)$$

where  $D_c$ =degree-days required for development of eggs,

$\text{ED}'_{a+n}$ =number of degree-days accumulated to day  $a+n$ ,

$\text{ED}'_a$ =number of degree-days accumulated to day  $a$ ,

and  $n$ =number of days required for egg development from day  $a$ .

Also calculated in GENLN are the lengths of the preoviposition and oviposition periods (equations 4 and 22). The development times are also adjusted for the percentage of difference between species.

### Moonlight (MOON)

This subroutine calculates the number of days, before or after, that each day of the simulation is from full moon. MOON then stores in the ADMOON array the proper moonlight adjustment factor,  $P_4$ , for egg laying.

### Insecticides (SPRAY)

This subroutine reads in daily mortalities caused by insecticides for eggs, small larvae, large larvae, pupae, adults, parasites, and predators for each species.

### Parasites (PARINP)

This subroutine calculates parasitism of eggs and larvae as described under "Egg Mortality."

### Predators (PRDINP)

This subroutine calculates predation of eggs and larvae as described previously under "Egg Mortality."

### Adult Moths (ADULT)

This subroutine calculates adult mortality as described previously.

### Crop Phenology (CROP)

This subroutine calculates the various phenological stages, the relative search area, and the number of sites (e.g., ears) for corn. Degree-days as previously described are used to make these predictions.

### Cannibalism (CANBAL)

This subroutine calculates the probability of cannibalism of *H. zea* larvae.

### Migration (MIGRAT)

This subroutine calculates the probability of moths migrating away from a particular crop.

### Field Population (FLDPOP)

This subroutine converts light-trap catches to field populations expressed as moths per acre (5, 7). The light-trap catches are adjusted for low night temperatures. Light-trap catches for 5 years (1970-74) were reduced significantly before June 10. The effect of temperature was large early (April) and decreased to nearly zero by June 10. Hardwick (4) also found a significant correlation between low night temperatures and light-trap catches. Figure 8 shows the effect of temperature on trap catch on four dates (Julian). We used a quadratic equation to calculate the adjustment for any particular day. The coefficients of the quadratic (A) and the base factor ( $F=26.7^{\circ}\text{C}$ ) are calculated by four linear equations whose variable is time (Julian date):

$$A1=812.4-5.8(\text{IDY}), \quad (24)$$

$$A2=28.6753+0.20281(\text{IDY}), \quad (25)$$

$$A3=0.252667-0.001762(\text{IDY}), \quad (26)$$

$$F=136.9-0.86667(\text{IDY}), \quad (27)$$

$$F'=A1+A2(\text{NA})+A3(\text{NA})^2, \quad (28)$$

$$\text{and TRAPIN}=F \div F', \quad (29)$$

where IDY=Julian date,  
F'=temperature factor,  
NA=average temperature from 1800 to 0600 hours ( $^{\circ}\text{F}$ ),  
and TRAPIN=adjustment factor for trap catch.

This adjustment is limited to the College Station, Tex., climate or a similar one. The time factor would have to be changed for areas where early-season temperatures differ significantly. These equations are only valid to day 153 of the simulation, and all temperatures below  $12.8^{\circ}\text{C}$  are assumed to be  $12.8^{\circ}\text{C}$ .

### Graph (GRAPH)

This subroutine may be used if a graph of the output or input is needed.

### *Heliothis* Population Input (EGGINP)

This subroutine reads in the *Heliothis* populations for initiating the simulation. These populations can be either eggs or moths. White eggs (eggs up to 1 day old) or total eggs can be used as input. The eggs are read in daily. If total eggs is used, EGGINP divides total egg num-

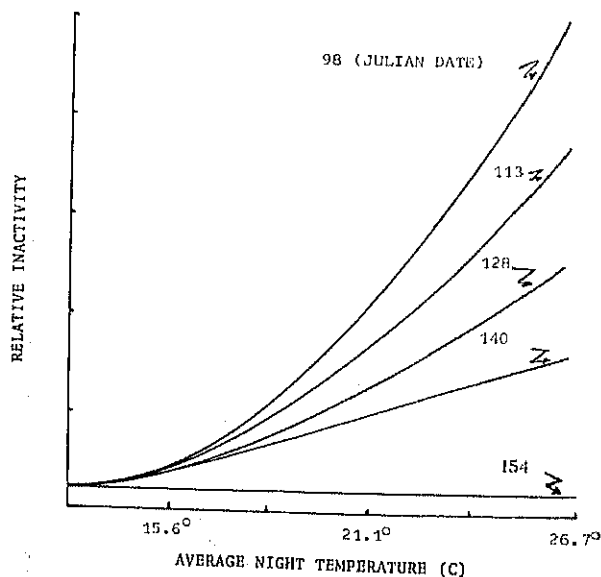


FIGURE 8.—Relative insect inactivity as a function of temperature at different times of the year compared to the inactivity on day 154.

ber by 0.31 to obtain an estimated white-egg count and moves the count to 3 days earlier.

Light-trap catches tabulated by sex or on a total basis can be used as input. Subroutine FLDPOP converts the catch to an estimated number of moths per acre. Male and female moth data are preferred if available because the sex ratio is calculated and used later by CROP to estimate egg-laying probability.

### Double Three-Day Moving Average (SMOOTH)

This subroutine applies a double 3-day moving average to insect population data.

### *Trichogramma* (TRKGRM)

This subroutine is a model of the population dynamics of *Trichogramma*. Development of *Trichogramma* in *Heliothis* eggs is controlled by temperature, and potential parasitism is controlled by number and age of adult *Trichogramma*. These relationships are described by

$$PTEMP_1 = |72 - TEMAVG_1| \quad (80)$$

$$\text{and } PTEMP_2 = 1.56 - 0.07(PTEMP_1), \quad (81)$$

where  $PTEMP_1$  = the degrees average daily temperature is from 72° F, imposing that if  $PTEMP_1 > 22$ ,  $PTEMP_1 = 22$  and if  $PTEMP_1 < 8$ ,  $PTEMP_1 = 8$ ,  
 $PTEMP_2$  = the activity factor of adult *Trichogramma* attributable to temperature,

$$\text{and } B_1 = -0.693 \div [(N)(SAREA)], \quad (82)$$

$$\text{and } B_2 = 1 - \exp [PARSIT(B_1)] \\ (PTEMP_2)(1 - POS), \quad (83)$$

where  $B_1$  = index of potential parasitism,  
 $B_2$  = probability of parasitism,  
 POS = mortality of parasites from insecticides,  
 SAREA = relative search area,  
 and  $N$  = number of *Trichogramma* adults required to parasitize 50% of eggs in 3 days (15,000).

The parasitized eggs are subject to death by predators and other natural agents and by insecticides until the *Trichogramma* emerge. It

is assumed that the parasites will live 10 days, that two female parasites will emerge from each egg, and that the number of eggs parasitized will increase as a function of search area (to account for eggs missed). The fertility rate of adult *Trichogramma* is read in as array FERATE.

### Function Distribution (DISTR)

DISTR calculates the development distributions of cohorts of eggs, larvae, and pupae. A normal distribution is assumed (22). The standard deviations (SDEV) are calculated in subroutine GENLN as a function of temperature (2). Array GAUS is the cumulative distribution function for eight standard deviations centered on the mean of the normal probability distribution.

## VALIDATION OF THE MODEL

*Heliothis* populations on corn, sorghum, and cotton were sampled at least two times a week during low populations and three or four times a week during peaks. The samples were taken by examining all plants in 6½ feet of row at six random locations in the field.

Simulations were run from April 1 to July 24, 1974, which covers the first three *Heliothis* generations. The first two *H. zea* generations at College Station oviposit primarily on corn and sorghum, and the third generation oviposits on cotton. It was assumed that the first two generations of *H. virescens* would oviposit primarily on wild hosts and that the third generation would move into cotton. Since no wild hosts were sampled, it was assumed that all eggs found on corn and sorghum were *H. zea*, an assumption verified by laboratory rearing of collected larvae. No counts of parasites or predators were made; therefore, option 3 was used in subroutines PARINP and PRDINP (fig. 5). Two simulations were run and compared with field-collected data.

*Light-trap input.*—Counts of *H. zea* males from two light traps (each having a 40-watt black-light lamp) located in a cornfield were used as model input from April 1 to May 20, 1974. These moths were assumed to have emerged from diapause. The next two generations were predicted and compared with actual field counts. Figure 9 shows the light-trap input converted to total eggs (April 1–May 20), the

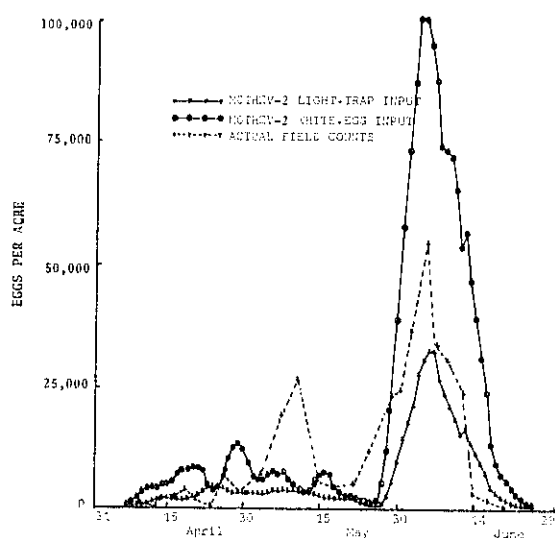


FIGURE 9.—Predicted and actual field counts of eggs. Input to model, April 1 to May 20, 1974.

predicted number of total eggs (May 21–June 29), and the number of eggs counted in the field. Actual hourly temperature was used for the entire simulation. The predicted June peak was 1 day late and the predicted number of eggs was low, the latter caused primarily by the light-trap model, probably one of the weakest parts of MOTHZV-2.

Figure 10 compares the predicted third generation of ovipositing moths migrating into cotton and the actual field count of eggs in cottonfields closest to the cornfield. The pre-

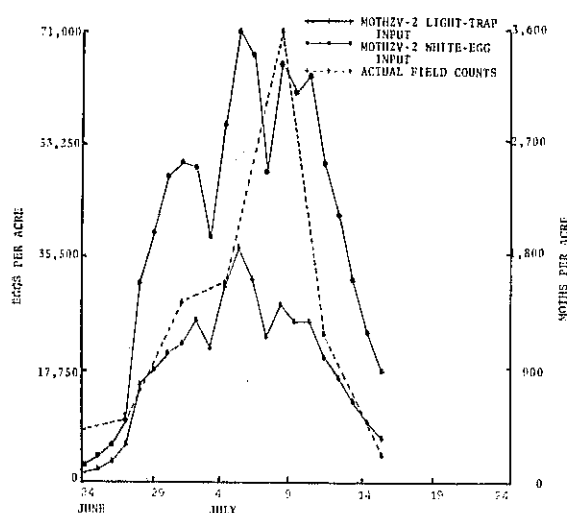


FIGURE 10.—Predicted number of moths migrating from corn and actual field counts of eggs in cotton. Input to model, April 1 to May 20, 1974.

dicted moth peak was 3 days ahead of field egg peak, as expected, since eggs would require 2 or 3 days to hatch.

*White-egg input.*—Counts of white eggs in the cornfield from April 1 to May 20 were used as input, and predictions of the next two generations were made. Figure 9 shows the white-egg input and the predicted second generation. The predicted peak was 1 day earlier than the actual peak, and the predicted egg peak was larger than the actual field peak. (Field scouts, bear in mind, are less than accurate. Moreover, many eggs may have been removed by predators before the count.) The predicted third generation moth peak was also 3 days before the actual egg peak in cotton.

Figures 11 and 12 show predicted and actual counts of small and large larvae. The dates of these peaks are very close; however, the magnitudes of the peaks vary similarly to the egg peaks, as discussed. Further validation of assumptions concerning development periods and mortalities could alleviate differences in magnitude. It is felt that the field measurements were in error, even though very competent entomological help was used, because it is impossible to find every egg or larva and because field counts were not made every day. A factor that may affect the size of the small and large larval peaks is the subjective judgment of which group to put them in. The model apparently is

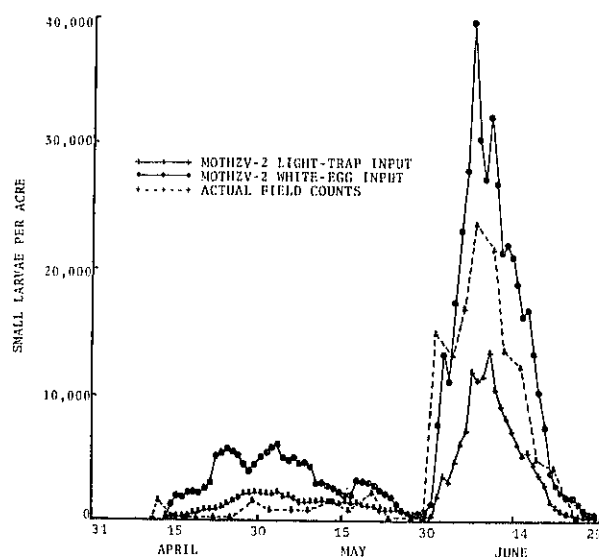


FIGURE 11.—Predicted and actual field counts of small larvae. Input to model, April 1 to May 20, 1974.

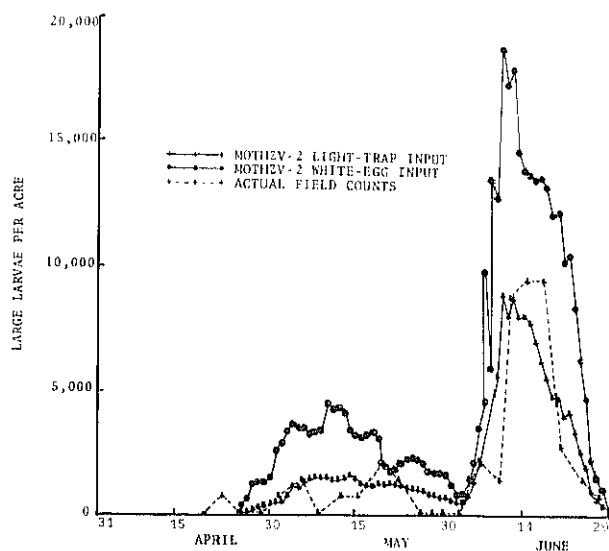


FIGURE 12.—Predicted and actual field counts of large larvae. Input to model, April 1 to May 20, 1974.

dividing them at an earlier age (1 day off) than does the field scout.

Similar results were obtained when data from previous years at College Station and Pearsall, Tex., were used. Simulation of *H. zea* in sorghum was also accomplished with similar results.

## DEFINITION OF TERMS

### Main Program

ADMOON	Moonlight adjustment calculated for each day.	EARS	Calculated corn ears per acre.
ADTS	Number of adults migrating on each day of simulation plus the number that migrated and survived previously.	ED	Array of degree-days calculated for <i>Heliothis</i> development and cotton growth.
ADTSMG	Average number of ovipositing adults that have migrated and survived.	EDCORN	Array of degree-days calculated for corn and sorghum development.
AGE	Number of days moth has been ovipositing.	EGGFRT	Percentage of <i>Heliothis</i> eggs that are fertile.
AP	Proportion of the eggs not hatched.	EGLYCR	Probability that a female will oviposit because of a crop factor.
APARA	Storage of number of eggs parasitized during simulation.	EGLYPR	Probability that a female will oviposit because of crop and temperature factors.
APOSON	Storage of number of eggs sterilized from insecticide during simulation.	EGLYTM	Average temperature (°F) during 3-hour period of maximum oviposition.
B	Used in calculation of probability of <i>Trichogramma</i> parasitism (option 4, KODE 5).	EGP	Maximum number of eggs a <i>Heliothis</i> moth will lay in 1 day.
BOLLS	Calculated cotton bolls per acre.	ELPDTA	Probability that a moth is at maximum egg production.
C	Mortality probabilities.	EQELAD	Relative number of female moths considered to be ovipositing at maximum rate.
CLOUD	Percentage of cloud cover read in for each hour.	FACTAA, FACTBB	Factors for averaging migration of moths from fields of the same crop.
DATX	Array of read-in data to be plotted with output.	FACTD	Calculated light-trap factor to correct trap catch to moths per acre.
DEATH	Natural mortalities of all stages of insects.	FM	Array of moonlight adjustment factors.
DEATHY	Mortality of adults the previous day.	FOODFK	Nutritional factor affecting development time of <i>Heliothis</i> .
DEGDAY	Array of degree-days required for each stage of <i>Heliothis</i> development.	HEADS	Calculated heads of sorghum per acre.
		IDX	Used for plotting DATX.
		IEND	Number of days a moth will produce eggs.
		IFIRST	Day number of first day of simulation (Julian).
		IFISTT	First day of temperature data to be read in and degree-days calculated (Julian).
		IFRUIT	Day number first silk appears in corn (Julian).
		IGEN	Array containing calculated average development times for all stages of <i>H. zea</i> and <i>H. virescens</i> .
		IGENV	Array containing calculated average development times for all stages of <i>H. virescens</i> .
		IGENZ	Array containing calculated average development times for all stages of <i>H. zea</i> .
		IGKODE	Plot code.
		IH	Code for <i>H. zea</i> .
		ILAST	Day number of last day of simulation (Julian).
		ILASTC	Day number of last day of input to model (Julian).
		ILASTT	Last day of temperature input and degree-days calculated (Julian).
		IPEAK	Number of days it takes an ovipositing moth to reach maximum egg production.
		IPX	Code for double 3-day moving average of migrating moths.
		ITOP	Number of days moth will be at maximum egg production.
		IV	Code for <i>H. virescens</i> .
		IXBAR	Mean length of pupal development time in days.
		JFIRST, JLASTC	Variables to flag feedback of moths.





DD	Degree-days required for corn or sorghum to develop from IA to peak silk or head.
DDA	Degree-days from corn and sorghum emergence to IA.
DDB	Degree-days from first square to first boll in cotton.
DDF	Degree-days from IA to IF in corn and sorghum.
DDM	Degree-days from first boll to maturity in cotton.
DELTA	Percentage of crop development per day.
DISTS	Percentage of eggs hatched.
IA	Day number when crop becomes attractive to <i>Heliothis</i> (Julian).
IE	Day number when crop emerges (Julian).
IF	Day number when first fruit appears (Julian).
IM	Day number when crop becomes fully mature (Julian).
IP	Day number when crop planted (Julian).
KCROP	Set to value of KODE 11 (crop).
NATRAC	Day number when crop becomes attractive to <i>Heliothis</i> (Julian).
PLANTS	Number of plants per acre.
S	Factor used to calculate normal distribution for development of fruit.
TP	Factor used to calculate normal distribution for development of fruit.
YIELD	Estimated yield of cotton bales per acre.
YIELDB	Calculated peak number of bolls.
YIELDS	Calculated peak number of squares.

### DISTR

GAUS,	Arrays of accumulated normal distributions used to vary development time of <i>Heliothis</i> .
GAUS1,	
GAUS2	

### EGGINP

B	Number of <i>H. zea</i> eggs in field on first day of simulation.
BEMALE	Number of <i>H. zea</i> females.
BMALE	Number of <i>H. zea</i> males.
C	Number of <i>H. virescens</i> eggs.
CFEMALE	Number of <i>H. virescens</i> females.
CMALE	Number of <i>H. virescens</i> males.
IDD	Used for calculation of missing egg data.
L	Set to code of type of input (eggs or moths).
X	Adjustment factor for total egg input.
XDL1,	Used for calculation of missing egg data.
XDL2	
XEGG	Used for adjustment of nutritional factor for sorghum.

### FLDPOP

A1,	Coefficients used in temperature adjustment of light-trap catches.
A2,	
A3	
E	Efficiency of light trap.

F	Base factor used in temperature adjustment of light-trap catches (26.7° C).
FD	Average distance (feet) a moth can fly in 1 night.
F1	Factor used in temperature adjustment of light-trap catches.
IN	Insect species code.
IPX	Code for locating light-trap data for double 3-day moving average.
R	Effective radius (feet) of light trap.

### GENLN

A1,	Coefficients for calculation of standard deviations in <i>Heliothis</i> development times.
A2,	
A3	
EDICK	Accumulated degree-days at start of <i>Heliothis</i> development.
IGENX	Used in calculation of <i>Heliothis</i> development times.
IKODE	Flags generation length calculations so that calculation of multiple simulations of same weather data will not be repeated.
IN	Insect species code.
IX	Used in calculation of <i>Heliothis</i> development time.
P	Percentage of difference in development time of <i>H. zea</i> and <i>H. virescens</i> .
X	Standard deviations for 1 day.

### GRAPH

B	Used for calculation of variable format.
DIGIT,	Arrays used for plotting.
DIGIT1,	
DIGIT2,	
INSECT	Array used for plot headings and identification.
ISTAGE	Array used for plot headings and identification.
ISTG	Used to calculate variable scale factors and printout.
K	Used for calculation of variable format.
KSTG	Used to calculate variable scale factors and printout.
NSCALE	Used to calculate variable scale factors and printout.
SCALE	Used to calculate variable scale factors and printout.
SXV	Code for <i>H. virescens</i> .
SXZ	Code for <i>H. zea</i> .
SXZV	Code for <i>H. zea</i> and <i>H. virescens</i> .
SX1	Used to calculate variable scale factors and printout.
VFA	Variable format used to plot data.
VFB	Variable format used to plot data.

### MIGRAT

XD	Day number crop becomes completely unattractive to <i>Heliothis</i> (Julian).
XM	Day number crop becomes mature (Julian).

## MOON

A	Set to day number of first full moon (Julian).
B	Day number of simulation (Julian).
J	Phase-of-moon code.

## PARINP

B, FX	Used to calculate percentage of parasitism.
L	Set to parasitism code (option).
N	Number of parasites per acre required to obtain 50% parasitism.
OLARPA	Number of naturally occurring parasites of <i>Heliothis</i> larvae per acre.
OTHERS	Number of naturally occurring parasites per acre.
PA	Percentage of maximum parasitism of eggs and larvae.
PEND	Last day of parasites in crop (Julian).
PDOWN	Start of downtrend of parasites (Julian).
PMAXI	First peak of parasites (Julian).
PMINI	Start of buildup of parasites (Julian).
POTHR	Probability of parasitism by naturally occurring parasites.
PTRICH	Probability of parasitism by <i>Trichogramma</i> .
TRICH	Number of released <i>Trichogramma</i> per acre.
X	Probability of egg parasitism.
Y	Probability of larval parasitism.

## PRDINP

ALB	Number of lady beetles per acre (specifically for data collected at Pecos, Tex.).
CALLOP	Number of callops per acre (specifically for data collected at Pecos, Tex.).
CHA	Number of <i>Chrysopa</i> adults per acre (specifically for data collected at Pecos, Tex.).
CHL	Number of <i>Chrysopa</i> larvae per acre (specifically for data collected at Pecos, Tex.).
CHRYSP	Number of released <i>Chrysopa</i> per acre.
HEMP	Number of Hemiptera per acre (specifically for data collected at Pecos, Tex.).
IFF, ILL	Used for calculating number of predators when actual counts are not available.
NE	Number of egg predators needed per acre to obtain 50% predation when search area=1.0.
NL	Number of larval predators needed per acre to obtain 50% predation when search area=1.0.
OTHEGG	Number of naturally occurring egg predators per acre.
OTHLAR	Number of naturally occurring larval predators per acre.
PCHRY	Probability of predation by released <i>Chrysopa</i> .
POTHR	Probability of predation by naturally occurring predators.

SP	Number of spiders per acre (specifically for data collected at Pecos, Tex.).
SPID	Number of spiders per acre.
X	Probability of predation of eggs.
Y	Probability of predation of small larvae.
Z	Probability of predation of large larvae.

## SMOOTH

IP	Factor used in double 3-day moving average.
IXF	First day of smoothed data.
S	Factor used in double 3-day moving average.
SM	Equivalent array used to calculate double 3-day moving average.

## SPRAY

P	Percentage of mortality of <i>Heliothis</i> stages, predators, and parasites on any one day.
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## TEMP

DAYLN	Number of hours of daylight on each day of simulation.
ET	Minimum temperature (°F) for <i>Heliothis</i> development.
IEGG	First hour of maximum oviposition after sunset.
T1	Minimum temperature (°F) for corn and sorghum development.
T2	Maximum temperature (°F) for corn and sorghum development.
TEM	Effective hourly degree-days for <i>Heliothis</i> .
TEMOVR	Number of degrees hourly temperature (°F) is over 92.
THP	Actual or expected daily high temperature (°F).
TLP	Actual or expected daily low temperature (°F).
TM	Actual or calculated hourly temperature (°F).

## TRKGRM

FERATE	Fertility rate of <i>Trichogramma</i> .
IAGE	Age of <i>Trichogramma</i> adults in days.
K	Mean development time for <i>Trichogramma</i> in days.
TS	Keeps track of number of parasitized <i>Heliothis</i> eggs.
X	Mortality factor.

## INPUT REQUIREMENTS

Device 05 or  
SYSIN: CODE  
FORMAT (2014)

CODE	Col. No.	Description
1	4	0 Leaves population input the same as in previous run.

		1 Reads in moths (total number).	9	36	0 No adjustment in trap catch.
		2 Reads in eggs (1-day-old).			1 Adjusts trap catch to moths per acre.
		3 Reads in moths (male and female).			2 Uses same adjustment as previous run.
		4 Reads in eggs (all ages).			
		5 Migration used as input.			
		6 Reads in total eggs with missing data.	10	38-40	xxx Day number that model should run to.
		7 Reads in 0- to 1-day-old eggs with missing data.	11	44	1 Corn.
					2 Sorghum.
					3 Cotton.
2	8	0 Temperature stays the same as in previous run; generation length stays same.			
		1 Reads in hourly temperature.	12	48	0 Leaves predator input the same as in previous run.
		2 Temperature stays the same as in previous run; generation length can be changed.			1 Reads in maximum predation.
		3 Reads in daily maximum and minimum temperature.			2 Reads in number of predators per day.
					3 Reads in percentage of predation on each day.
					4 Reads in number of predators with incomplete data.
Note: Always read in temperature for at least 1 day before and 30 days after time of simulation of crop or insect.					
			13	52	0 Leaves natural mortalities the same as in previous run.
3	12	0 No moonlight effect on insect.			1 Reads in natural mortalities, egg fertility, and the maximum number of eggs per moth per day.
	10-12	xxx Day number of first full moon in January (add 1 for leap year).			
4	16	0 No mortalities from insecticides.	14	56	0 Leaves crop phenology the same as in previous run.
		1 Reads in insecticide mortality.			1 Reads in crop phenology.
		2 Leaves input the same as in previous run.	15	60	0 Leaves migration the same as in previous run.
					1 Calculates migration.
5	20	0 Leaves input the same as in previous run (0 to 1st run).			
		1 Reads in maximum parasitism.	16	62	0 Log plot of data.
		2 Reads in number of parasites on each day.			1 Linear plot of data.
		3 Reads in percentage of parasitism for each day.		63-64	xx Number of plots wanted.
		4 Reads in number of <i>Trichogramma</i> and generates future populations.	17	68	0 No cannibalism.
					1 Calculates cannibalism of larvae.
6	24	0 Migration not calculated.			
		1 Migration away from crop.	18	72	1 This run is for <i>H. zea</i> and <i>H. virescens</i> .
		2 Migration into crop as input.			2 This run is for <i>H. virescens</i> only.
7	26-28	Not used.			3 This run is for <i>H. zea</i> only.
8	32	0 No smoothing of data.			
		1 Smooths trap catch by a double 3-day moving average.	19	76	0 No cloud cover input, clear sky assumed.
					1 Input cloud cover and use.

Device 05 or  
 SYSIN: Mortalities, egg fertility, and egg  
 laying  
 KODE (13)=1 or more  
 FORMAT (2 (6F4.3, F4.0) )

Column No.	Description
1-4	<i>H. zea</i> : Natural mortality of eggs (% ÷ 100).
5-8	<i>H. zea</i> : Natural mortality of 1- to 3-instar larvae.
9-12	<i>H. zea</i> : Natural mortality of 4- and 5-instar larvae.
13-16	<i>H. zea</i> : Natural mortality of pupae.
17-20	<i>H. zea</i> : Natural mortality of adults.
21-24	<i>H. zea</i> : Egg fertility.
25-28	<i>H. zea</i> : Maximum number of eggs per female per day.
29-32	<i>H. virescens</i> : Natural mortality of eggs.
33-36	<i>H. virescens</i> : Natural mortality of 1- to 3-instar larvae.
37-40	<i>H. virescens</i> : Natural mortality of 4- and 5-instar larvae.
41-44	<i>H. virescens</i> : Natural mortality of pupae.
45-48	<i>H. virescens</i> : Natural mortality of adults.
49-52	<i>H. virescens</i> : Egg fertility.
53-56	<i>H. virescens</i> : Maximum number of eggs per female per day.

Device 05 or  
 SYSIN: Days of population data on device 11  
 KODE (1)=1 or more  
 FORMAT (2I4)

Column No.	Description
1-4	First day of initial population data to be read in.
5-8	Last day of initial population data to be read in.

Device 05 or  
 SYSIN: Days of temperature data on device 15  
 and device 16  
 KODE: (2)=1 or 3  
 FORMAT (2I4)

Column No.	Description
1-4	First day of temperature data to be read in and degree-days calculated.
5-8	Last day of temperature data to be read in and degree-days calculated.

Note: Reading switches automatically to device 16 when end-of-file encountered on device 15. Sufficient days of input should be allowed for crop growth and multiple-run situations.

Device 05 or  
 SYSIN: Crop phenology  
 KODE (14)=1  
 FORMAT (4I6, F6.0, I6, 5F3.2)

Column No.	Description
1-6	Day number of planting date of crop, IP.
7-12	Day number of emergence date of crop, IE.
13-18	Day number when first fruit appeared, IF.
19-24	Day number when crop became mature, IM.
25-30	Number of plants per acre.
31-36	Day number when crop becomes attractive to moths, IA.
37-39	Percentage of the area in corn.
40-42	Percentage of the area in sorghum.
43-45	Percentage of the area in cotton.
46-48	Percentage of the area in pasture.
49-52	Percentage of the area in other crops.

Device 05 or  
 SYSIN: Maximum parasitism  
 KODE (5)=1 or 4  
 FORMAT (2F6.3)

Column No.	Description
1-6	Maximum parasitism of eggs (% ÷ 100). Set to zero if KODE (5)=4.
7-12	Maximum parasitism of 1- to 3-instar larvae (% ÷ 100).

Device 05 or  
 SYSIN: Maximum predation  
 KODE (12)=1  
 FORMAT (2F6.3)

Column No.	Description
1-6	Maximum predation of eggs (% ÷ 100).
7-12	Maximum predation of 1- to 3-instar larvae (% ÷ 100).

Device 05 or  
 SYSIN: Plot control  
 KODE (16) less than 200  
 FORMAT (36I2), 1 card required for each plot wanted (10 curves per plot maximum)

[Put a 1 in column indicated for desired plot]				
		Column number		
Scale <sup>1</sup>	Information plotted	<i>H. zea</i>	<i>H. virescens</i>	Both spp.
1	Total eggs .....	2	26	50
1	Small larvae (1- to 3-instar) .....	4	28	52
1	Large larvae (4- to 5-instar) .....	6	30	54

[Put a 1 in column indicated for desired plot]

Scale <sup>1</sup>	Information plotted	Column number		
		<i>H. zea</i>	<i>H. virescens</i>	Both spp.
1	Pupae .....	8	32	56
2	Preovipositing adults .....	10	34	58
2	Ovipositing adults ..	12	36	60
2	Input data (as adults) .....	14	38	62
2	Migrating adults ...	16	40	64
1	Parasitized eggs ...	18	42	66
2	Predicted ovipositing adults equivalents.	20	44	68
1	Other variable scale (1) .....	22	46	70
2	Other variable scale (2) .....	24	48	72

<sup>1</sup> 1 based on maximum eggs; 2 based on maximum preovipositing adults.

Device 05 or  
SYSIN: KRUN  
(always required)  
FORMAT (I3)

KRUN designates the status of additional runs to be made. Values greater than zero indicate that additional runs are to be made, and a value of zero (blank) indicates that the present input is the final run to be made.

If the migration outputs from several runs are to be averaged for input to a second crop, special sequential values should be coded as follows: for corn, 11, 12, 13, . . . 19; for sorghum, 21, 22, 23, . . . 29; for cotton, 31, 32, 33, . . . 39.

KRUN indicates the field number associated with the data following the KRUN card. The value of KRUN for the first data set entered is assigned automatically by the program depending on the crop type selected. For a series of three corn fields and two sorghum fields followed by a cotton field the input sequence would be as follows: corn data 1 with KRUN=12, corn data 2 with KRUN=13, corn data 3 with KRUN=21, sorghum data 1 with KRUN=22, sorghum data 2 with KRUN=31, cotton data with KRUN=0. The average migration from the three corn fields would then be added to the average migration from the sorghum and used as input to the cotton with the proper selection of constants on the KODE cards. If independent multiple runs are to be made, values of KRUN from 1 to 9 should be used. No averaging of output will take place.

Device 11: Moth or egg input

A. KODE (1)=1: Moth input (initial population= males + females)  
FORMAT (I6, 4F6.1), 1 card for each day

Column No.	Description
1-6	Day number.
7-12	<i>H. zea</i> : Number of males.

13-18	<i>H. zea</i> : Number of females.
19-24	<i>H. virescens</i> : Number of males.
25-30	<i>H. virescens</i> : Number of females.

B. KODE (1)=2: Egg input (0- to 1-day-old)  
FORMAT (9x, I3, 2F6.0), 1 card for each day

Column No.	Description
10-12	Day number.
13-18	<i>H. zea</i> : Number of eggs.
19-24	<i>H. virescens</i> : Number of eggs.

C. KODE (1)=3: Moth input (initial population= 2 times number of males, sex ratio calculated)  
FORMAT (I6, 4F6.1), card for each day

Same as A above

D. KODE (1)=4: Egg input (all ages)  
FORMAT (9x, I3, 2F6.0)

Same as B above

E. KODE (1)=5: Migration of *H. zea* moths from corn or sorghum or both; moth input of *H. virescens* if KODE (18)=1 or 2  
FORMAT (I6, 12x, 2F6.1)

Same as A above; enter zero for *H. zea*.

F. KODE (1)=6: Egg input (all ages) with missing data  
FORMAT (18x, 2F6.0, I3), 1 card for each day that data are available; computer will calculate missing days. Cards must be in order by date.

Column No.	Description
19-24	<i>H. zea</i> : Number of eggs.
25-30	<i>H. virescens</i> : Number of eggs.
37-39	Day number.

G. KODE (1)=7: Egg input (0- to 1-day-old) with missing data

Same as F above

Device 12: Insecticide mortalities  
FORMAT (I6, 14F4.3), 1 card for each day there is mortality

Column No.	Description
1-6	Day number.
7-10	<i>H. zea</i> : Parasites (%÷100).
11-14	<i>H. zea</i> : Predators.
15-18	<i>H. zea</i> : 1- to 3-instar larvae.
19-22	<i>H. zea</i> : 4- and 5-instar larvae.
23-26	<i>H. zea</i> : Pupae.
27-30	<i>H. zea</i> : Adults.

31-34	<i>H. zea</i> : Eggs.
35-38	<i>H. virescens</i> : Parasites.
39-42	<i>H. virescens</i> : Predators.
43-46	<i>H. virescens</i> : 1- to 3-instar larvae.
47-50	<i>H. virescens</i> : 4- and 5-instar larvae.
51-54	<i>H. virescens</i> : Pupae.
55-58	<i>H. virescens</i> : Adults.
59-62	<i>H. virescens</i> : Eggs.

### Device 13: Parasites

A. KODE (5) = 2  
FORMAT (I6, 3F6.0)

Column No.	Description
1-6	Day number.
7-12	Number of <i>Trichogramma</i> released.
13-18	Number of natural egg parasites.
19-24	Number of natural larval parasites.

B. KODE (5) = 3  
FORMAT (I6, 2F6.3)

Column No.	Description
1-6	Day number.
7-12	Parasitism of eggs (% $\div$ 100).
13-18	Parasitism of larvae (% $\div$ 100).

C. KODE (5) = 4  
FORMAT (I6, F6.0)

Column No.	Description
1-6	Day number.
7-12	Number of <i>Trichogramma</i> .

### Device 14: Predators

A. KODE (12) = 2  
FORMAT (9X, I3, 6F6.0, 6X, 2F6.0, 6X, F6.0)  
(Special format for handling 1973-74  
Frio County, Tex., data.)

Column No.	Description
10-12	Day number.
13-18	Number of <i>Scymnus</i> .
19-24	Number of other Coccinellidae.
25-30	Number of other Coleoptera.
31-36	Number of <i>Orius</i> .
37-42	Number of <i>Geocoris</i> .
43-48	Number of other Hemiptera.
55-60	Number of <i>Chrysopa</i> immatures.
67-72	Number of spiders.
73-78	Number of released <i>Chrysopa</i> .

B. KODE (12) = 3  
FORMAT (I6, 2F6.2)

Column No.	Description
1-6	Day number.
7-12	Predation of eggs (% $\div$ 100).
13-18	Predation of larvae (% $\div$ 100).

C. KODE (12) = 4  
FORMAT (6X, 6F5.0, I3) (Special format for  
handling 1974 Pecos, Tex., data.)

Column No.	Description
7-11	Number of spiders.
12-16	Number of adult lady beetles.
17-21	Number of other Hemiptera.
22-26	Number of <i>Chrysopa</i> larvae.
27-31	Number of <i>Chrysopa</i> adults.
32-36	Number of Coleoptera.
37-39	Day number.

### Devices 15 and 16: Air temperature

A. KODE (2) = 1: Read from device 15  
FORMAT (2X, I3, 3X, 24F3.0): Measured hourly  
temperature, 1 card per day

Column No.	Description
3-5	Day number.
9-11	Average temperature from 0000 to 0100 hours.
12-14	Average temperature from 0100 to 0200 hours.
....	.....
78-80	Average temperature from 2400 to 0100 hours.

B. KODE (2) = 3 or end of file on device 15: Read  
from device 16. Sufficient data  
corresponding to final day speci-  
fied for temperature input on  
SYSIN must be provided.  
FORMAT (I3, 2F3.0): Measured high and low  
for each day.

Column No.	Description
1-3	Day number.
4-6	Measured high temperature for day.
7-9	Measured low temperature for day.

### Device 17: Cloud cover

KODE (19) = 1: First and last day read in  
correspond to temperature  
data. On end-file condition  
program uses last data read  
in for remainder of days of  
input requested. Final card  
should show desired cloud  
conditions accordingly.

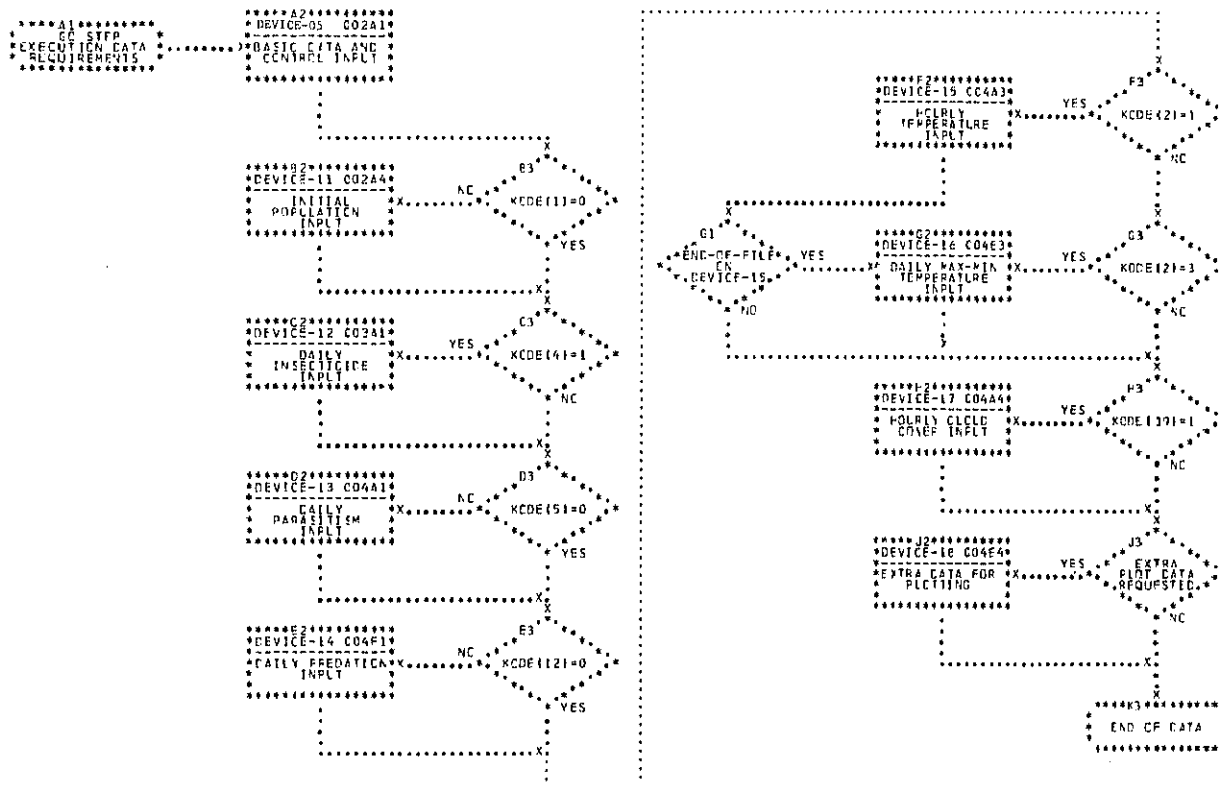
FORMAT (2X, I3, 3X, 24F3.0)

Column No.	Description
3-5	Day number.
9-11	Cloud cover from 0000 to 0100 hours.
12-14	Cloud cover from 0100 to 0200 hours.
....	.....
78-80	Cloud cover from 2400 to 0100 hours.

Device 18: Extra data to be added to print plot for comparison with model output.  
 FORMAT (6X, I6, F6.0)

Column No.	Description
7-12	Day number.
13-18	Data value.

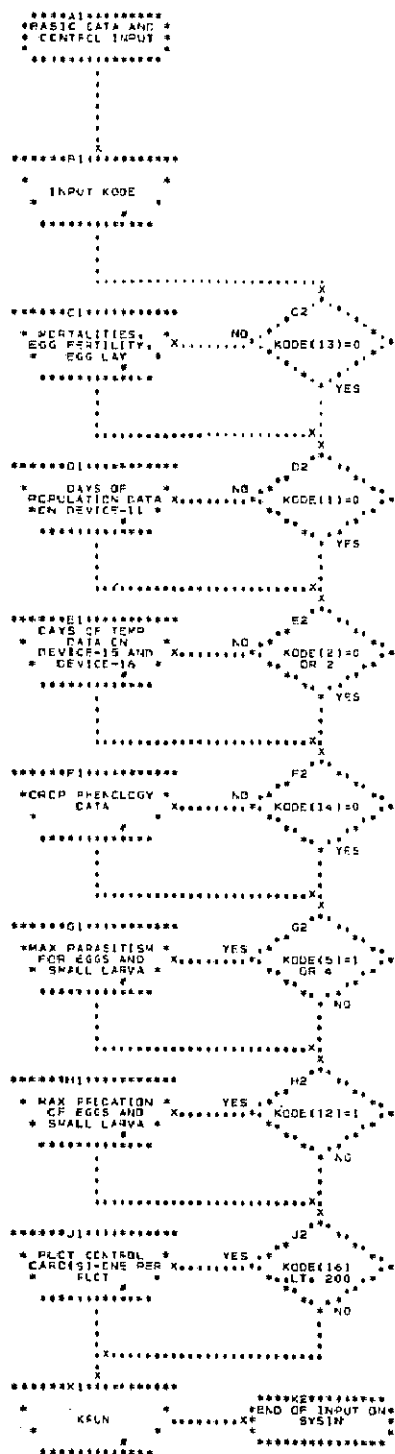
\*\*\*\*\*  
 MCHZV2 - LCAD MODULE  
 \*\*\*\*\*



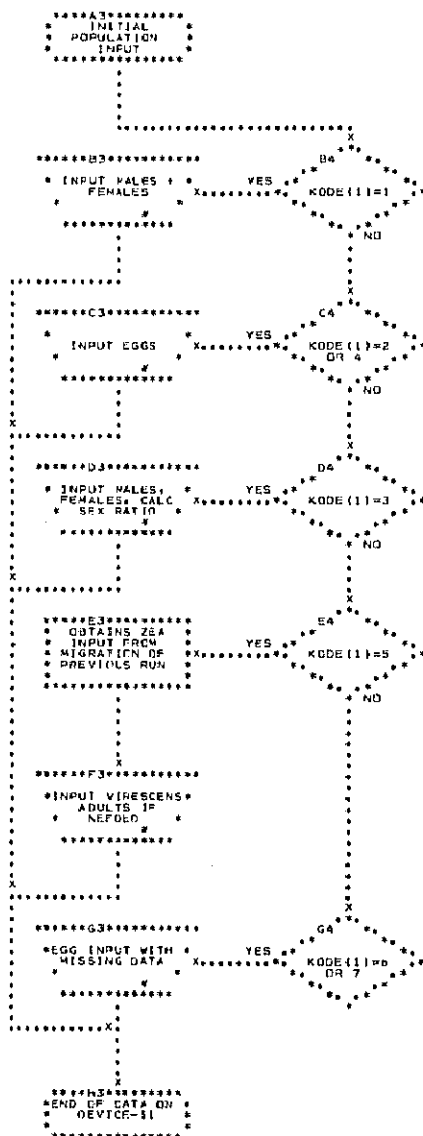


NOTHZV2 - LOAD MODULE  
INPUT REQUIREMENTS

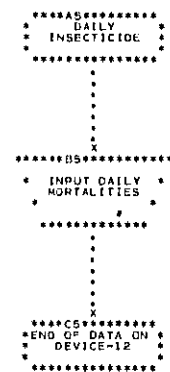
SYSDN



DEVICE-11

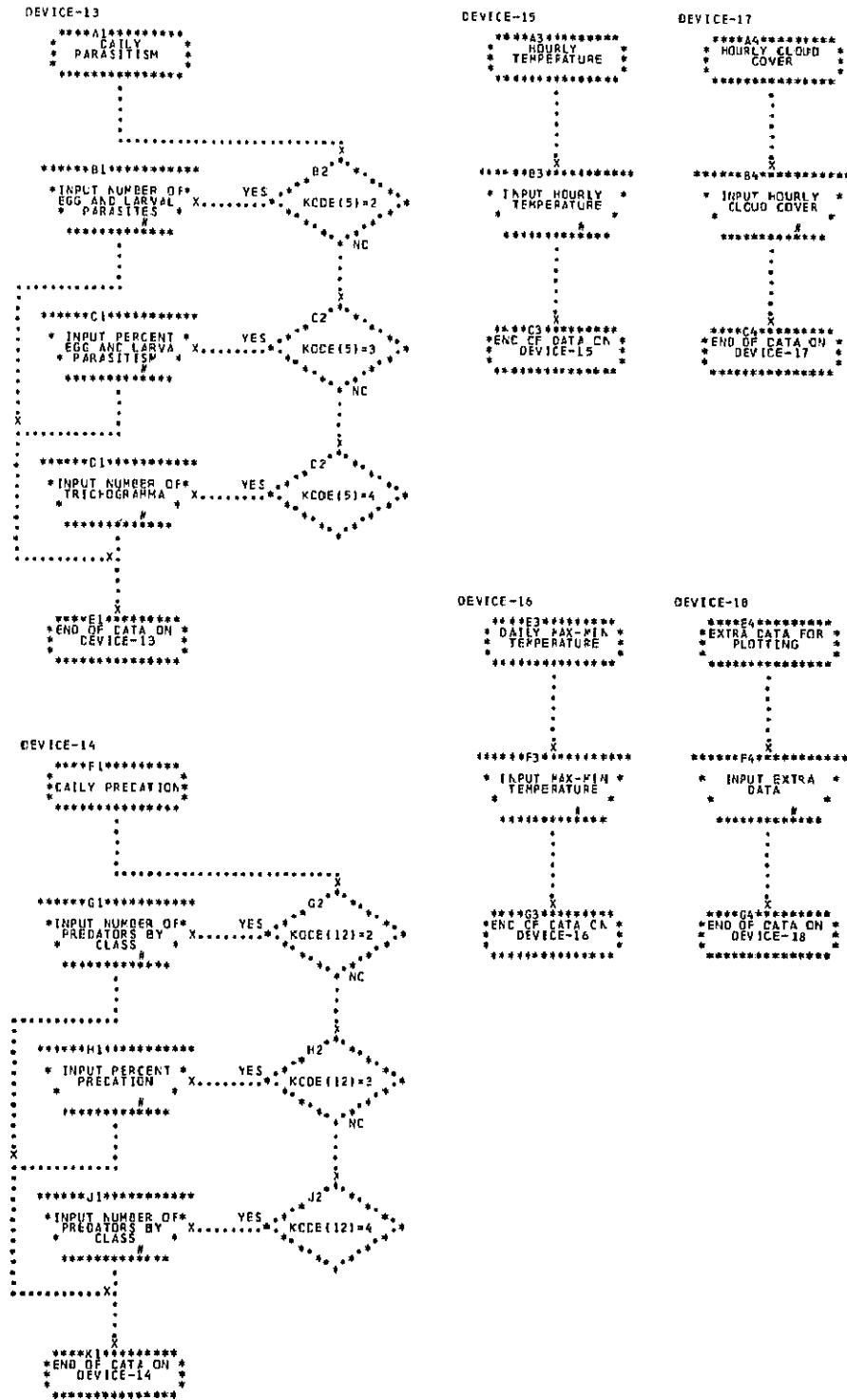


DEVICE-12



B1, FORMAT (2014)  
C1, FORMAT  
(2(6F4,3,F4,0))  
D1, FORMAT(2(4))  
E1, FORMAT(214)  
F1, FORMAT  
(416,F6,0,16,5F3,2)  
G1, FORMAT(2F6,3)  
H1, FORMAT(2F6,3)  
J1, FORMAT(3612)  
K1, FORMAT(13)  
B3, FORMAT(16,4F6,1)  
C3, FORMAT(9X,13,2F6,0)  
D3, FORMAT(16,4F6,1)  
F3, FORMAT(16,12X,2F6,1)  
G3, FORMAT  
(18X,2F6,0,13)  
B5, FORMAT(16,14F4,3)

## NC74V2 - LCAD MODULE INPUT REQUIREMENTS



```

B1. FORMAT(I6,3F6.0)
C1. FORMAT(I6,2F6.3)
D1. FORMAT(I6,F6.0)
E1. FOR FRIQ CC, DATA
  FORMAT(9X,I3,F6.0,6X,Z
  F6.0,6X,F6.0)
H1. FORMAT(I6,2F6.2)
J1. FOR PCFOS DATA
  FORMAT(6X,6F5.0,I3)
B3.
  FORMAT(2X,I3,3X,24F3.0)
F3. FORMAT(I3,2F3.0)
B4.
  FORMAT(2X,I3,3X,24F3.0)
F4. FORMAT(6X,I6,F6.0)

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# PROGRAM LISTING

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1 C MOTHZV 2 MODEL OF THE HELIOTHIS ZEA AND VIRESCENS BY A. W. HARTSTACK
2 C ROOM 231 AGRICULTURAL ENGINEERING BLDG. USDA ARS COLLEGE STATION,
3 C TEXAS
4 REAL NITMIN
5 REAL SLPOP(370), LLPOP(370), PPOP(370), POAPOP(370)
6 COMMON KODE(20), FACTD, SDEV(370,4), NITMIN(370), ED(370), EDCORN(300),
7 ASQUARE(370), BOLLS(370), EARS(370), HEADS(370), S(4), POP(370), EGLYTM(3
8 C70), IFIRST, ILASTC, IH, IV, ADMOON(370), SAREA(370), TCLUD(370), ILAST,
9 JKRUN, SEXRTO(370,2), EGPEMT(2), PCTCRP(5), IGEN(370,7,2), TEMAVG(370),
10 EEQELAD(370,2), ADTSMG(370,2,2), TOTAL(370,9,2), POS(370,7,2), PARST
11 F(370,2), PREDOR(370,2), PRMGRT(370,2), IA, IM, L, I, DEATHY, SURV, EGLYPR(
12 G370,2), PLANTS, KCROP, IS, SITES(369), R, DF, EGLYCR(370,2), CANLAR, JJ, KK,
13 HNN, XPOP, N, PP, IN, K, SRVIVE, X, IPX, IGKODE(12,3), DATX(370), TP, DEATH(5,2
14 I), XBAR, XSD, DIST, IFISTT, ILASTT, IE, PRBLAR, PRBNEW
15 DIMENSION SS(2)
16 DIMENSION ZZERO(2590), ZONE(16280), ZTWO(740), ZTHREE(1854)
17 DIMENSION EGGFRT(2), EGP(2), TOTMGS(370,2), CLOUD(24)
18 DIMENSION FM(30)
19 DIMENSION PDERTE(7), POLRTE(7), PRED(7)
20 DIMENSION TMEA(800)
21 DIMENSION DEAUT(25)
22 DIMENSION DEGDAY(6,2)
23 DIMENSION ADTS(370,2)
24 DIMENSION PCTMG(2)
25 DIMENSION SITEOC(370)
26 EQUIVALENCE (ZZERO(1), SLPOP(1)), (ZZERO(371), LLPOP(1)),
27 D (ZZERO(741), PPOP(1)), (ZZERO(1111), POAPOP(1)),
28 E (ZZERO(1481), SITEOC(1)), (ZZERO(1851), TOTMGS(1,1))
29 EQUIVALENCE (ZONE(1), EEQELAD(1,1))
30 EQUIVALENCE (ZTWO(1), ADMOON(1))
31 EQUIVALENCE (ZTHREE(1), SQUARE(1))
32 DO 1 I=1,370
33 1 TCLUD(I)=0.0
34 C INITIALIZE TO ZERO VARIABLES NOT IN COMMON.
35 DO 9 I=1,2590
36 9 ZZERO(I)=0.0
37 C INITIALIZE TO ZERO VARIABLES EEQELAD THRU PRMGRT IN COMMON.
38 DO 19 I=1,16280
39 19 ZONE(I)=0.0
40 C INITIALIZE TO ONE VARIABLES ADMOON THRU SAREA IN COMMON.
41 DO 29 I=1,740
42 29 ZTWO(I)=1.0
43 C INITIALIZE TO ZERO VARIABLES SQUARE THRU POP IN COMMON.
44 DO 39 I=1,1854
45 39 ZTHREE(I)=0.0
46 C KRUN=0 MEANS THE INITIAL SIMULATION. KRUN=1 MEANS GREATER THAN 1-
47 C ADDITIONAL SIMULATION. IFIRST-DAY NO. FIRST DAY OF SIMULATION. ILAST
48 C -DAY NO OF FINAL DAY OF SIMULATION.
49 IDX=0
50 KRUN=0
51 C KODE=1-20 OPTIONS.
52 34 READ(5,500)(KODE(I), I=1,20)
53 500 FORMAT(20I4)
54 ILAST=KODE(10)
55 C IH-CODE FOR HELIOTHIS ZEA- IV CODE FOR HELIOTHIS VIRESCENS.
56 IH=1
57 IV=2
58 IF(KODE(18).EQ.2) IH=2
59 IF(KODE(18).EQ.3) IV=1
60 IF(KRUN.EQ.0) GO TO 7
61 IF(KODE(13).EQ.0) GO TO 37
62 C DEATH-NATURAL MORTALITY FOR EGGS, SMALL LARVAE, LARGE LARVAE, PUPAE,
63 C ADULTS. EGGFRT-FERTILITY OF EGGS, EGPEMT-EGGS PER FEMALE MOTH.
64 7 READ(5,506)((DEATH(I,J), I=1,5), EGGFRT(J), EGPEMT(J), J=1,2)
65 506 FORMAT(2(6F4,3,F4,0))
66 DO 38 I=IH,IV
67 EGP(I)=EGPEMT(I)
68 38 EGPEMT(I)=EGPEMT(I)/2.
69 37 IF(KODE(1).EQ.0) GO TO 60
70 C EGGIMP-SUBROUTINE FOR INPUTING INITIAL POPULATIONS. TOTAL-ARRAY OF
71 C VARIOUS POPULATION STAGES. ILASTC-LAST DAY OF INITIAL INPUT DATA READ
72 C IN. FACTD-LIGHT TRAP CONVERSION FACTOR. ADTSMG-ADULTS MIGRATING
73 C INTO CROP. SEXRTO-SEX RATIO MALES-FEMALES. PCTCRP-PERCENTAGE OF
74 C OVERALL AREA IN EACH CROP SIMULATED.
75 READ(5,500) IFIRST, ILASTC
76 CALL EGGIMP
77 IF(KRUN.EQ.0) GO TO 62
78 60 KF=IFIRST-1
79 DO 61 I=KF, ILAST
80 SLPOP(I)=0.
81 LLPOP(I)=0.
82 PPOP(I)=0.

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83      POAPOP(I)=0.
84      DATX(I)=0.
85      DO 61 K=IH,IV
86      TOTMGS(I,K)=0.0
87      EGELAD(I,K)=0.0
88      TOTAL(I,8,K)=0.0
89      TOTAL(I,9,K)=0.0
90      DO 61 J=1,6
91      61 TOTAL(I,J,K)=0.0
92      62 CONTINUE
93      IF(KODE(2).EQ.0.OR.KODE(2).EQ.2) GO TO 2
94      C READS IN TEMPERATURE
95      C TEMP-SUBROUTINE USED TO READ IN TEMP AND OTHER VARIABLES.
96      C ED-ACCUMALATED DEGREE DAYS USED FOR INSECT + COTTON- TEMAVG-AVERAGE
97      C TEMP PER DAY. EDCORN-ACCUMALATED DEGREE DAYS FOR CORN.
98      C EGLYTM-TEMP DURING THE PERIOD WHEN THE MOTH LAYS EGGS.
99      C NITMIN-AVERAGE TEMP DURING THE NIGHT- TCLUD-AVERAGE CLOUD COVER
100      C DURING THE PERIOD WHEN THE MOTH IS LAYING EGGS.
101      READ(5,500) IFISTT,ILASTT
102      CALL TEMP
103      C GENLIN-SUBROUTINE USED FOR CALCULATING DEVELOPING TIMES FOR ALL
104      C STAGES OF INSECT. IGEN- ARRAY OF DEVELOPMENT TIMES FOR VARIOUS STAGES
105      C OF INSECT. IGENZ- ARRAY OF DEVELOPMENT TIMES FOR HELIOTHIS ZEA.
106      C IGENV-ARRAY FOR DEVELOPMENT TIMES FOR HELIOTHIS VIR.
107      C SDEV-STANDARD DEVIATION OF DEVELOPMENT TIMES VARIOUS STAGES.
108      2 CALL GENLN
109      C CROP-SUBROUTINE FOR CALCULATING CROP PHENOLOGY. EGLYPR-EGGLAY
110      C PROBABILITY.
111      C PLANTS-NO. OF PLANTS PER ACRE.
112      C SQUARE-NO. OF SQUARES PER ACRE.
113      C BOLLS- NO OF BOLLS PER ACRE. EARS- NO OF EARS PER ACRE.
114      C HEADS- NO OF SORGHUM HEADS PER ACRE. KCROP- CODE FOR CROP.
115      C IA-CODE FOR 1ST ATTRACTNESS OF CROP. IM-DAY WHEN CROP REACHES
116      C MATURITY.
117      C SAREA-SEARCH AREA FOR PARASITES AND PREDATORS. IS-DAY NO WHEN CROP
118      C IS MAX ATTRACTANCE. SITES-NO. OF SITES FOR EGG LAYING.
119      C DF-DISPERSION FOR NEGATIVE BINOMIAL. EGLYCR-ATTRACTANCE OF CROP FOR
120      C EGG LAY.
121      CALL CROP
122      IF(KODE(5).EQ.0) GO TO 33
123      C PARIMP-SUBROUTINE FOR CALCULATING PARASITIZATION.
124      C PARSIT-PERCENT PARASITIZATION CALCULATED.
125      32 CALL PARIMP
126      33 IF(KODE(12).EQ.0) GO TO 35
127      C PRDIMP-SUBROUTINE FOR PREDATION INPUT. PREDOR- PERCENT PREDATION
128      C CALCULATED.
129      CALL PRDIMP
130      35 CONTINUE
131      5 IF(KODE(3).EQ.0) GO TO 3
132      C MOON-SUBROUTINE FOR CALCULATING REDUCTION OF EGG LAY DUE TO
133      C MOONLIGHT.
134      C ADMOON-PERCENT REDUCTION OF EGG LAY OF MOONLIGHT CALCULATED.
135      CALL MOON
136      3 CONTINUE
137      C SPRAY-SUBROUTINE FOR INPUTTING INSECTICIDE MORTALITY.
138      C POS-PERCENT MORTALITY DUE TO INSECTICIDE.
139      CALL SPRAY
140      63 IF(KODE(9).EQ.0) GO TO 36
141      C FLDPPOP-SUBROUTINE FOR CONVERTING LIGHT TRAP CATCH TO MOTHS PER ACRE.
142      C FACTD-CALCULATED FACTOR FOR CONVERTING LIGHT TRAP CATCH.
143      CALL FLDPPOP
144      GO TO 64
145      C FACTD-EQUALS 1 IF INPUT IS NOT LIGHT TRAP CATCHES.
146      36 FACTD=1.0
147      64 CONTINUE
148      C NEXT SERIES OF CARDS PRINT OUT READ IN AND CALCULATED INPUT DATA-
149      C FOR USE IN SIMULATION.
150      IF(KODE(18).EQ.1)WRITE(6,708)
151      IF(KODE(19).EQ.2)WRITE(6,710)
152      IF(KODE(18).EQ.3)WRITE(6,707)
153      707 FORMAT(' INPUT FOR THE MODEL HAS BEEN HELIOTHIS ZEA ONLY')
154      708 FORMAT(' INPUT FOR THE MODEL HAS BEEN HELIOTHIS ZEA AND VIRESCEN'
155      X)
156      710 FORMAT(' INPUT FOR THE MODEL HAS BEEN HELIOTHIS VIRESCEN ONLY')
157      WRITE(6,7070) IFIRST,ILASTC
158      7070 FORMAT(' ', 'INPUT READ FROM', I4, ' TO ', I4)
159      4 WRITE(6,75)FACTD,KRUN,EGGFRT(1),EGGFRT(2),EGP(1),EGP(2),PLANTS
160      75 FORMAT(' ', 2X, 'FACTD=', F6.3, 2X 'RUN NO.=', I3, 'ZEA EGGFRT=', F6.3, 'VI
161      XRS EGGFRT=', F6.3, /, 'ZEA EGGS/MOTH =', F6.0, ' VIRS EGGS/MOTH=', F6.0
162      X, 'PLANTS/ACRE=', F6.0, /)
163      WRITE(6,7700) IE, IA, IS, IM
164      7700 FORMAT(' ', 'CROP PHENOLOGY: IE=', I3, ', IA=', I3, ', IF=', I3, ', IM=', I3/
165      C)
166      WRITE(6,76)
167      76 FORMAT(' DAY NO. EGGPART 1-3PAR EGGPRD 1-3PRD TCLUD NITMIN TEMAVG

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168      2 ADMOON EGLYTM SQUARES BOLLS EARS HEADS SAREA')
169      DO 70 I=IFIRST,ILAST
170      WRITE(6,79)I,(PARSIT(I,J),J=1,2),(PREDOR(I,J),J=1,2),TCLDUD(I),NIT
171      2MIN(I),TEMAVG(I),ADMOON(I),EGLYTM(I),SQUARE(I),BOLLS(I),EARS(I),HE
172      3ADS(I),SAREA(I)
173      79 FORMAT(' ',17,4F7.3,3F7.1,F7.3,F7.1,4F7.0,F7.1)
174      70 CONTINUE
175      DO 72 IN =IH,IV
176      WRITE(6,603)
177      603 FORMAT(' ',//,30X,'NATURAL MORTALITY',/,',', EGGS 1-3 LARVAE 4-5 L
178      XARVAE PUPAE*,6X,'ADULTS')
179      WRITE(6,604) (DEATH(I,IN),I=1,5)
180      604 FORMAT(12F10.3)
181      WRITE(6,77)
182      77 FORMAT('1 DAYNO. POSPAR POSPRD POS1-3 POS4-5 POSPUP POSADT POSEGG
183      2EGG 1-3 4-5 PUP ADP ADD E-E EGYPR EGYCR PRMGRT SEXRTO')
184      IF(IN.EQ.1)WRITE(6,605)
185      IF(IN.EQ.2)WRITE(6,606)
186      DO 72 I=IFIRST,ILAST
187      WRITE(6,78)I,(POS(I,J,IN),J=1,7),(IGEN(I,J,IN),J=1,7), EGYLP
188      2R(I,IN),EGLYCR(I,IN),PRMGRT(I,IN),SEXRTO(I,IN)
189      78 FORMAT(' ',17,7F7.3,7I4,3F7.3,2F7.2)
190      72 CONTINUE
191      WRITE(6,81)
192      81 FORMAT(' KK I SITES PRBLAR PRBNEW')
193      720 CONTINUE
194      C IFRUIT-ESTIMATED TO BE 9 DAYS PRIOR TO THE LAST SILKS TO APPEAR.
195      C (CORN ONLY)
196      IFRUIT=IM-9
197      IF(KODE(1).EQ.0) KODE(1)=KKODE
198      KKODE=KJDE(1)
199      C START OF MAIN POPULATION LOOP.
200      DO 200 IN =IH,IV
201      C FOODFK-NUTRIENT VALUE OF CROP CORN LEAVES-1.0-MILD 1.1/ CORN EARS .65
202      C COTTON-1.0 FOR ZEA---ALL CROPS 1.0 FOR VIRESCEN
203      C FOODFK-VARIABLE USED TO INCREASE OR REDUCE LENGTH OF LARVAE
204      C DEVELOPMENT.
205      FOODFK=1.1
206      IF(KCROP.EQ.1) FOODFK=1.
207      IF(IN.EQ.2) FOODFK=1.0
208      IF(KCROP.EQ.3) FOODFK=1.0
209      C NN-VARIABLE USED TO FLAG WHEN DAY OF SIMULATION IS IFRUIT OR
210      C GREATER (CORN ONLY).
211      NN=0
212      TSITOC=0.
213      JFIRST=IFIRST
214      JLASTC=ILASTC
215      C MAIN POPULATION LOCP.
216      DO 200 K=IFIRST,ILAST
217      521 CONTINUE
218      C KTRAP-CODE NAME OF TYPE OF INPUT.
219      KTRAP=KJDE(1)
220      IF(KODE(6).EQ.2)GO TO 51
221      IF(K.GT.ILASTC) GO TO 50
222      GO TO (52,520,52,520,8,520,520),KTRAP
223      GO TO 8
224      C POP NO 0-1 DAY OLD EGGS. EQELAD-NUMBER OF EQUIVALENT EGG LAYING
225      C ADULTS.
226      C TOTAL-(K,7,IN) INPUT DATA CONVERTED TO MOTHS PER ACRE.
227      C K-DAY NUMBER OF SIMULATION. IN-SPECIES OF INSECT.
228      C STATEMENT 50 51 USED ONLY WHEN INPUT IS MIGRATING MOTHS.
229      51 POP(K-1)=(EQELAD(K-1,IN)+(TOTAL(K-1,7,IN)*EGLYPR(K-1,IN)))*EGPEMT(
230      1 IN)*ADMOON(K-1)
231      GO TO 8
232      C STATEMENT 50 USED ONLY WHEN DAY OF SIMULATION IS PAST LAST DAY
233      C OF INPUT.
234      C GENERATED EQELAD IS USED AS INPUT.
235      50 POP(K-1)=EQELAD(K-1,IN)*EGPEMT(IN)*ADMOON(K-1)*EGLYPR(K-1,IN)
236      GO TO 8
237      C STATEMENT 52 IS USED WHEN INPUT IS LIGHT TRAP CATCHES.
238      52 POP(K-1)=TOTAL(K-1,7,IN)*EGPEMT(IN)*EGLYCR(K-1,IN)
239      GO TO 8
240      C STATEMENT 520 IS USED WHEN INPUT IS EGGS.
241      520 POP(K-1)=TOTAL(K-1,7,IN)*EGPEMT(IN)
242      C APOSON-STORAGE OF NUMBER EGGS STERILIZED FROM INSECTICIDE.
243      C APARA-STORAGE OF NUMBER OF EGGS PARASITIZED.
244      8 CONTINUE
245      APOSON=0
246      APARA=0
247      TOTPAR=0
248      TOTPOS=0
249      IF(POP(K-1).LT.1.)GO TO1100
250      C XBAR-DAY NUMBER THAT THE MEAN NUMBER OF EGGS HATCHED. XSD-SDEV-(K,1)
251      C STANOARD DEVIATION OF EGGS HATCHED DUE TO TEMPERATURE.
252      C DIST%- THE PERCENTAGE OF EGGS HATCHED.

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253      XBAR=K+IGEN(K,1,IN)-1
254      XSD=SDEV(K,1)
255      DISTS=0.
256 C   SRVIVE=NO OF FERTILE EGGS REMAINING IN THE POPULATION AFTER ALL
257 C   MORTALITIES.
258 C   AP=THE PERCENTAGE OF EGGS NOT HATCHED.
259      SRVIVE=POP(K-1)*EGGFRT(IN)
260      AP=1.
261 C   BEGINNING OF EGG LCOP.
262      DO 100 I=K,ILAST
263      IF(SRVIVE.LT.1.)GO TO 1100
264      C=PREDOR(I,1)*(1.-POS(I,2,IN))
265 C   TT=THE PROBABILITY THAT EGGS WILL SURVIVE NATURAL MORTALITIES AND
266 C   PREDATION. TP=THE NO. OF EGGS PARASITISED-ASSUMES IF OVICIDE APPLIED
267 C   THAT IT WOULD ALSO KILL PARASITE EGG.
268 C   TPP=THE NO. OF EGGS STERILIZED BY OVICIDE
269 C   PARASITISED EGGS ARE ASSUMED TO REMAIN IN FIELD 10 DAYS
270 C   INFERTILE EGGS ARE ASSUMED TO REMAIN IN FIELD FOR 3 - 4 DAYS
271 C   TINF-TOTAL INFERTILE EGGS IN POPULATION.
272      10 TT=(1.-C)*(1.-DEATH(I,IN))
273      POP(I)=POP(I-1)*TT
274      IF(KODE(5).NE.4)GO TO 1120
275      PTEMP=ABS(72.-TEMAVG(I))
276      IF(PTEMP.GT.22.)PTEMP=22
277      IF(PTEMP.LT.8.)PTEMP=8
278      PTEMP=1.56-.07*PTEMP
279      B=-.693/(15000.*SAREA(I))
280      B=(1.-EXP(PARSIT(I,1)*3))*PTEMP*(1.-POS(I,1,IN))
281      TP=(POP(I)-APARA)*B*(1.-POS(I,7,IN))
282      CALL TRKGRM
283      GO TO 1121
284 1120 CONTINUE
285      B=PARSIT(I,1)*(1.-POS(I,1,IN))
286      TP=(POP(I)-APARA)*B*(1.-POS(I,7,IN))
287      CALL TRKGRM
288 1121 CONTINUE
289      SRVIVE=SRVIVE*TT*(1.-B)*(1.-POS(I,7,IN))
290      APARA=(APARA*TT)+TP
291      TPP=POP(I)*POS(I,7,IN)
292      APOSON=(APOSON*TT)+TPP
293      TINF=(POP(I)-APARA)*(1.-EGGFRT(IN))+APOSON
294 C   TOTAL=(I,8,IN)TOTAL NUMBER OF EGGS IN POPULATION ON DAY I.
295      TOTAL(I,8,IN)=TCTAL(I,8,IN)+TINF
296      IF(AP.LT..0001)GO TO 1110
297      X=I
298 C   ZZ=NO OF EGGS THAT HATCHED ON DAY OF SIMULATION.
299      ZZ=SRVIVE*DISTR(DISTS)/AP
300      GO TO 1111
301 1110 ZZ=SRVIVE
302 1111 CONTINUE
303      AP=1.-DISTS
304      POP(I)=POP(I)-ZZ
305 C   SLPOP=NO. OF 1 DAY OLD SMALL LARVAE.
306      SLPOP(I+1)=SLPOP(I+1)+ZZ
307      SRVIVE=SRVIVE-ZZ
308 C   TOTAL=(I,1,IN)TOTAL NO. OF EGGS IN POPULATION ON DAY I. PARENTHIS
309 C   INCLUDING INFERTILE AND PARASITIZED EGGS.
310      TOTAL(I,1,IN)=TCTAL(I,1,IN)+POP(I)-APARA+TP
311 100 CONTINUE
312 1100 CONTINUE
313 C   CHECK TO SEE IF LARVAE IS DEVELOPING ON EARS.
314      IF(KODE(11).EQ.1.AND. K.GE.IFRUIT) FOODFK=.65
315 C   SMALL LARVAE ARE EXPOSED TO PARASITES AND PREDATORS FOR ONLY
316 C   2DAYS WHEN SILKS ARE AVAILABLE FOR SITES
317      IF (KODE(11).EQ.1.AND. K.GE.IFRUIT) NV=1
318 C   PP=TEMPORARY STORAGE OF SMALL LAEVAE 0 TO 1 DAY OLD ON DAY K.
319 C   LX-CALCULATION OF APPROX. DAYS REQUIRED FOR DEVELOPMENT OF SMALL
320 C   LARVAE.
321      PP=SLPOP(K)
322      LX=IGEN(K,2,IN)*FOODFK+.5
323      L=K
324      IF(SLPOP(K).LT.1.)GO TO 1201
325 C   XBAR- MEANS DAY NUMBER WHEN SMALL LARVAE BECOMES LARGE LARVAE.
326 C   XSD-SDEV(K,2)STANDARD DEVIATION FOR SMALL LARVAE DEVELOPMENT.
327 C   DISTS=PERCENTAGE OF SMALL LARVAE THAT HAVE DEVELOPED INTO LARGE
328 C   LARVAE.
329      XBAR=K+LX-1
330      XSD=SDEV(K,2)
331      DISTS=0.
332      SRVIVE=SLPOP(K)
333 C   SRVIVE-TEMPORARY STORAGE OF SMALL LARVAE SURVIVING.
334      AP=1.
335 C   AP=PERCENTAGE OF SMALL LARVAE THAT HAVE NOT DEVELOPED IN TO LARGE
336 C   LARVAE.
337      N=0

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338 C N-AGE OF SMALL LARVAE.
339 XPOP=0.
340 C XPOP-TOTAL NO. OF SMALL LARVAE CANNABIALIZED BY LARGER LARVAE.
341 CANLAR=0.
342 C CANLAR-NO. OF SMALL LARVAE CANNABIALIZED BY OTHER LARVAE OF THE SAME
343 C SIZE.
344 C START OF SMALL LARVAE LOOP.
345 DO 101 I=K,ILAST
346 IF(SRVIVE.LT.1.)GO TO 1200
347 N=N+1
348 C CHECK TO SEE IF SMALL LARVAE ARE ON CORN SILKS.
349 IF(NN.EQ.1.AND.N.GT.2) GO TO 14
350 D =PARSIT(I,2)*(1.-POS(I,1,IN))
351 C EQUATION WHICH REDUCES PREDATION PERCENT LEVEL DUE TO AGE OF SMALL
352 C LARVAE.
353 E =(EXP(-.42*N)/.657)*PREDOR(I,2)*(1.-POS(I,2,IN))
354 GO TO 13
355 14 D=0.
356 E=0.
357 13 T=(1.-D)*(1.-E)*(1.-DEATH(2,IN))*(1.-POS(I,3,IN))
358 SRVIVE=SRVIVE*T
359 KK=I
360 C JJ-CODE TO OPERATE CANNIBALISM SUBROUTINE.
361 JJ=365
362 C CANNIBAL-SUBROUTINE THAT CALCULATES CANNIBALISM FOR ZEA LARVAE.
363 CALL CANBAL
364 1301 X=I
365 IF(AP.LT..0001) GO TO 1210
366 C ZZ- NUMBER OF SMALL LARVAE THAT HAVE DEVELOPED INTO LARGE LARVAE ON
367 C DAY OF SIMULATION.
368 ZZ=SRVIVE*DISTR(DISTS)/AP
369 GO TO 1211
370 1210 ZZ=SRVIVE
371 1211 CONTINUE
372 AP =1.-DISTS
373 C LLPOP-NO OF LARGE LARVAE 0-1 DAY OLD.
374 LLPOP(I+1)=LLPOP(I+1)+ZZ
375 SRVIVE=SRVIVE-ZZ
376
377 C TOTAL(I,2,IN) TOTAL NUMBER OF SMALL LARVAE IN THE POPULATION ON
378 C DAY I.
379 TOTAL(I,2,IN)=TOTAL(I,2,IN)+SRVIVE
380 101 CONTINUE
381 1200 CONTINUE
382 1201 CONTINUE
383 C LLPOP-LARGE LARVAE POPULATION (0-1 DAY OF AGE).
384 SRVIVE=LLPOP(K)
385 L=K-LX+1
386 IF(L.LT.IFIRST) L=K
387 C L ESTIMATES DAY WHEN EGGS WERE LAID ON FRESH SILKS FOR CANNIBALISM
388 C OF LARGE LARVA.
389 JJ=0
390 CALL CANBAL
391 WRITE(6,600)L,KK,R,PRBLAR,PRBNW
392 600 FORMAT(2I7,F10.0,2F7.3)
393 IF(LLPOP(K).LT.1)GO TO 1300
394 C IGEN-(K,3,IN) DEVELOPMENT TIME FOR LARGE LARVAE.
395 C LX-DEVELOPMENT TIME FOR LARGE LARVAE ADJUSTED FOR NUTRITION.
396 C XBAR-DAY NO. WHEN THE MEAN NUMBER OF LARGE LARVAE WILL PUPATE.
397 C XSD-STANDARD DEVIATION FOR PUPATION.
398 C DISTS-PERCENT OF LARGE LARVAE THAT HAVE PUPATED.
399 C AP- PERCENT OF LARGE LARVAE THAT HAVE NOT PUPATED.
400 LX=IGEN(K,3,IN)*FOCDFK+.5
401 XBAR=K+L X-1
402 XSD=SDEV(K,3)
403 DISTS=0.
404 AP=1.
405 C START OF LARGE LARVAE LOOP.
406 DO 102 I=K,ILAST
407 IF(SRVIVE.LT.1.)GO TO 1300
408 T=(1.-DEATH(3,IN))*(1.-POS(I,4,IN))
409 C T-MORTALITY DUE TO INSECTICIDE AND NATURAL MORTALITY.
410 C SRVIVE-NO. OF LARGE LARVAE SURVIVING.
411 SRVIVE=SRVIVE*T
412 X=I
413 IF(AP.LT..0001) GO TO 1310
414 ZZ=SRVIVE*DISTR(DISTS)/AP
415 C ZZ-NO OF LARGE LARVAE THAT HAVE PUPATED ON DAY OF SIMULATION.
416 GO TO 1311
417 1310 ZZ=SRVIVE
418 1311 CONTINUE
419 AP =1.-DISTS
420 C PPOF-NO. OF PUPAE.
421 PPOP(I+1)=PPOP(I+1)+ZZ
422 SRVIVE=SRVIVE-ZZ

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423 C TOTAL-(I,3,IN) TCTAL NO. OF LARGE LARVAE IN THE POPULATION, ALL AGES
424 C ON DAY OF SIMULATION.
425 TOTAL(I,3,IN)=TOTAL(I,3,IN)+SRVIVE
426 102 CONTINUE
427 C SRVIVE-NO. OF PUPAE (0-1 DAY OLD)
428 1300 SRVIVE=PPOP(K)
429 IF(PPOP(K).LT.1)GO TO 1400
430 C I XBAR-XBAR- DAY NO. WHEN THE MEAN NUMBER OF PUPAE BECOME ADULTS.
431 C XSD-STANDARD DEVIATION OF EMERGING ADULTS.
432 C DISTS=PERCENT OF PUPAE THAT HAVE EMERGED.
433 C AP- PERCENT OF PUPAE THAT HAVE NOT EMERGED.
434 I XBAR=K+IGEN(K,4,IN)-1
435 XBAR=IXBAR
436 XSD=SDIV(K,4)
437 DISTS=0.
438 AP=1.
439 C START OF PUPAE LOOP.
440 DO 103 I=K,ILAST
441 IF(SRVIVE.LT.1)GO TO 1400
442 C SRVIVE-NO. OF PUPAE SURVIVING MORTALITYS.(INSECTICIDE + NATURAL)
443 SRVIVE=SRVIVE*(1.-DEATH(4,IN))*(1.-POS(I,5,IN))
444 X=I
445 IF(AP.LT..0001) GO TO 1410
446 C ZZ- NO. OF PUPAE THAT HAVE EMERGED ON DAY OF SIMULATION.
447 ZZ=SRVIVE*DISTR(DISTS)/AP
448 GO TO 1411
449 1410 ZZ=SRVIVE
450 1411 CONTINUE
451 AP =1.-DISTS
452 SRVIVE=SRVIVE-ZZ
453 C POAPOP-NO. OF PRE-OVIPOSITIONING ADULTS.(0-1 DAY OF AGE).
454 POAPOP(I+1)=POAPOP(I+1)+ZZ
455 TOTAL(I,4,IN)=TOTAL(I,4,IN)+SRVIVE
456 C TOTAL-(I,4,IN)TOTAL NO. OF PRE OVIPOSITIONING ADULTS ALL AGES IN
457 C POPULATION.
458 103 CONTINUE
459 1400 CONTINUE
460 C JJ-CAY NO. WHEN THE MEAN NUMBER OF PRE-OVIPOSITIONED MOTHS BECOME
461 C OVIPOSITIONED ADULTS.
462 JJ=K+IGEN(K,5,IN)
463 IF(POAPOP(K).LT.1.)GO TO 202
464 IF(JJ.GT.ILAST)JJ=ILAST
465 C SRVIVE-NO. OF PRE-OVIPOSITIONING ADULTS(0-1 DAY OF AGE).
466 C L- AGE COUNTER OF ADULTS.
467 C DEATHY-MORTALITY OF ADULTS FROM PREVIOUS DAY.
468 SRVIVE=POAPOP(K)
469 L=1
470 DEATHY=0.0
471 C ADTS- NO. OF ADULTS MIGRATING ON DAY OF SIMULATION PLUS THE NUMBER
472 C OF ADULTS THAT HAVE MIGRATED AND SURVIVED FROM THE PREVIOUS DAY FOR
473 C THIS PARTICULAR CHORT.
474 ADTS(K-1,IN)=0.0
475 C START OF PRE-OVAPOSITIONING LOOP.
476 DO 104 I=K,JJ
477 C ADULT-SUBROUTINE USED FOR CALCULATIONS FOR NATURAL MORTALITY DUE TO
478 C TEMPERATURE.
479 C SURV=PERCENT SURVIVED TO THE NEXT DAY.
480 CALL ADULT
481 SRVIVE=SRVIVE*SURV *(1.-DEATH(5,IN))*(1.-POS(I,6,IN))
482 IF(KODE(6).EQ.0)GO TO 1041
483 IF(KODE(11).EQ.3) GO TO 1041
484 C THIS REDUCES THE NUMBER OF ADULTS IN CROP EACH DAY BY THE PERCENT
485 C PROBABILITY THAT THEY HAVE MIGRATED AWAY.
486 ADTS(I,IN)=ADTS(I-1,IN)*SURV *(1.-DEATH(5,IN))+SRVIVE *PRMG
487 1RT(I,IN)
488 C ADTSMG-TOTAL NO. OF ADULTS THAT HAVE MIGRATED FROM A PARTICULAR CROP
489 C ON DAY OF SIMULATION.(ALL AGES)
490 ADTSMG(I,KCROP,IN)=ADTSMG(I,KCROP,IN)+ADTS(I,IN)
491 SRVIVE=SRVIVE*(1-PRMGRT(I,IN))
492 1041 CONTINUE
493 C TOTAL-(I,5,IN) TOTAL NO OF PRE-OVIPOSITIONED ADULTS ON DAY OF
494 C SIMULATION. (ALL AGES)
495 TOTAL(I,5,IN)=TOTAL(I,5,IN)+SRVIVE
496 104 L=L+1
497 LL=L-1
498 C T-TEMPERATURE SUM OF RUNNING AVERAGE.
499 C AGE-LENGTH OF TIME MOTH IS BEING OVIPOSITIONED.
500 T=0.
501 AGE=0.
502 KK=JJ+1
503 IF(KK.GT.ILAST)GO TO 202
504 C JJ-MEAN LENGTH OF CUIPOSITIONING PERIOD.
505 JJ=JJ+IGEN(K,6,IN)
506 IF(JJ.GT.ILAST)JJ=ILAST
507 C START OF OVAPOSITIONED LOOP.

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508      DO 105 I=KK,JJ
509      AGE=AGE+1.0
510      T=T+TEMP*VG(I)
511      C TRUN=RUNNING DAILY AVERAGE TEMPERATURE.
512      TRUN=T/AGE
513      IF (TRUN.LT.55.) GO TO 1052
514      C IPEAK=NO. OF DAYS IT TAKES AN OVIPOSITIONING MOTH TO REACH MAX.EGG
515      C PRODUCTION.
516      IPEAK=(3029282.9*(TRUN)**(-3.111))+.4
517      IF (L.LT.IPEAK) GO TO 1053
518      C ITOP=NO. OF DAYS MOTH WILL BE AT MAX PRODUCTION OF EGGS.
519      ITOP=(239741.3*(TRUN)**(-2.615402))+.5
520      IPEAK=IPEAK+ITOP
521      IF (L.LE.IPEAK) GO TO 1054
522      C IEND=NO. OF DAYS AN OVIPOSITIONING MOTH WILL PRODUCE EGGS.
523      IEND=(916998.7*(TRUN)**(-2.53))+.5
524      IF (L.GE.IEND) GO TO 1052
525      XS=L-IPEAK
526      XB=IEND-IPEAK
527      C ELPDTA=PROBABILITY THAT A MOTH IS AT MAX. EGG PRODUCTION.
528      ELPDTA=1.-XS/XB
529      GO TO 1060
530      1052 ELPDTA=0.0
531      GO TO 1060
532      1053 XS=L-LL
533      XF=IPEAK-LL
534      ELPDTA=XS/XF
535      GO TO 1060
536      1054 ELPDTA=1.0
537      GO TO 1060
538      C REDUCES PROBABILITY OF MAX PRODUCTION OF EGGS EFFECTED BY MOONLIGHT.
539      1060 ELPDTA=ELPDTA
540      CALL ADULT
541      SRVIVE=SRVIVE*SURV*(1.-DEATH(5,IN))*(1.-POS(1,6,IN))
542      IF (KODE(6).EQ.0) GO TO 1051
543      IF (KCROP.GT.2) GO TO 1051
544      ADTS(I,IN)=ADTS(I-1,IN)*SURV*(1.-DEATH(5,IN))+SRVIVE*PRMGRT(
545      2 I,IN)
546      ADTSMG(I,KCROP,IN)=ADTSMG(I,KCROP,IN)+ADTS(I,IN)
547      C TOTMGS=TOTAL NO. OF OVIPOSITIONING ADULTS THAT HAVE MIGRATED AND
548      C SURVIVED.
549      TOTMGS(I,IN)=TOTMGS(I,IN)+ADTS(I,IN)*ELPDTA
550      SRVIVE=SRVIVE*(1.-PRMGRT(I,IN))
551      1051 CONTINUE
552      C EQELAD=EQUIVILANT EGG LAYING ADULTS (TOTAL NO. OF OVIPOSITIONING
553      C ADULTS.
554      C REMAINING IN CROP, ADJUSTED FOR EGG LAY POTENTIAL AND MOONLIGHT)
555      EQELAD(I,IN)=EQELAD(I,IN)+SRVIVE*ELPDTA
556      C TOTAL=(I,6,IN) TOTAL NO. OF OVIPOSITIONING ADULTS IN POPULATION -
557      C ALL AGES ON DAY OF SIMULATION.
558      TOTAL(I,6,IN)=TOTAL(I,6,IN)+SRVIVE
559      105 L=L+1
560      202 IF (KODE(7).NE.K) GO TO 200
561      605 FORMAT(' ',25X,'BOLLWORM HELIOTHIS ZEA')
562      606 FORMAT(' ',25X,'TOBACCO BUDWORM HELIOTHIS VIRESCENS')
563      200 CONTINUE
564      C PRINTOUT OF ALL POPULATION TOTALS.
565      DO 1070 IN=1H,IV
566      WRITE(6,608)
567      608 FORMAT('1',25X,'PRINTOUT OF TOTAL POPULATION OF VARIOUS LIFE STAGE
568      *S ON ANY DAY')
569      IF (IN.EQ.2) GO TO 1071
570      WRITE(6,605)
571      GO TO 1072
572      1071 WRITE(6,606)
573      1072 WRITE(6,610)
574      610 FORMAT(' DAY NO. EGGS 1ST-3RD 4TH-5TH PUPAE P ADULT O ADULT
575      2 INPUT EQELAD MIGRATS IN EGGS PAR EGG TOTMGS TRICHS')
576      IF (KCROP.GT.2) KCROP=2
577      FACTBB=KRUN-(KCROP*10.)-1.
578      FACTAA=FACTBB/(FACTBB+1.)
579      FACTBB=FACTBB+1.
580      DO 107 K=IFIRST,ILAST
581      IF (KRUN.LT.11) GO TO 1076
582      ADTSMG(K,KCROP,IN)=ADTSMG(K,KCROP,IN)*FACTAA+TOTMGS(K,IN)/FACTBB
583      GO TO 1077
584      1076 ADTSMG(K,KCROP,IN)=TOTMGS(K,IN)
585      1077 CONTINUE
586      IF (KODE(16).GE.200) GO TO 1073
587      IF (S(IN).LT.TOTAL(K,1,IN)) S(IN)=TOTAL(K,1,IN)
588      IF (S(IN+2).LT.TOTAL(K,7,IN)) S(IN+2)=TOTAL(K,7,IN)
589      IF (S(IN+2).LT.EQELAD(K,IN)) S(IN+2)=EQELAD(K,IN)
590      IF (S(IN+2).LT.ADTSMG(K,KCROP,IN)) S(IN+2)=ADTSMG(K,KCROP,IN)
591      1073 CONTINUE
592      TOT9=(TOTAL(K,9,IN)/(TOTAL(K,1,IN)+1.))*100.

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593      WRITE(6,602)K,(TOTAL(K,J,IN),J=1,7),EQELAD(K,IN),ADTSMG(K,KCROP,IN
594      1),TOTAL(K,8,IN),TOT9,TOTMGS(K,IN),PARSIT(K,1)
595      602 FORMAT(' ',I6,12F8.0,F8.1,F8.0)
596      TOTAL(K,8,IN)=ADTSMG(K,KCROP,IN)
597      107 CONTINUE
598      IF(IN.EQ.2) GO TO 1070
599      IPX=13
600      C SMOOTH-SUBROUTINE FOR APPLYING 3 DAY MOVING AVERAGE TO ADULTS THAT
601      C HAVE MIGRATED.
602      ILASTC=ILAST
603      CALL SMOOTH
604      1070 CONTINUE
605      IF (KJDE(16).GE.200)GO TO 1075
606      C SETS FLAGS FOR PLOT OF DATA.
607      IF(KODE(16).GE.100) NPLOT=KODE(16)-100
608      IF(KODE(16).LT.100) NPLOT =KODE(16)
609      DO 1074 I=1,NFLCT
610      READ(5,510)((IGKODE(J,K),J=1,12),K=1,3)
611      510 FORMAT(36I2)
612      K1=11
613      K2=12
614      DO 1082 K=1,3
615      DO 1081 J=K1,K2
616      IF(IGKODE(J,K).EQ.0) GO TO 1081
617      IF(IDX.EQ.0) GO TO 552
618      DO 1083 KJ=IFIRST,ILAST
619      C DATX-ARRAY FOR STORING FIELD DATA OF INSECT POPULATION WANTED ON
620      C PLOT TO COMPARE TO SIMULATED WEATHER.
621      1083 DATX(KJ)=0.
622      IDX=1
623      552 READ(18,551,END=1081)ID,X
624      551 FORMAT(6X,I6,F6.0)
625      IF(ID.EQ.0) GO TO 1081
626      DATX(ID)=X
627      GO TO 552
628      1081 CONTINUE
629      1082 CONTINUE
630      C GRAPH-SUBROUTINE FOR PLOTTING VARIOUS STAGES FOR INSECT POPULATION.
631      CALL GRAPH
632      1074 CONTINUE
633      1075 CONTINUE
634      C CHECK TO SEE IF THIS IS LAST SIMULATION WITH INSECT POPULATION.
635      READ(5,550,END=1085) KRUN
636      550 FORMAT(I3)
637      IF(KRUN.EQ.0) STOP
638      DO 1080 I=1,4
639      1080 S(I)=0.0
640      GO TO 34
641      1065 STOP
642      END

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1      SUBROUTINE ADULT
2      C THIS SUBROUTINE CALCULATES MORTALITY RATES FOR ADULTS AS DESCRIBED
3      C IN TEXT.
4      COMMON KODE(20),DUM60(11788),TEMAVG(370),DUM61(16282),L,I,DEATHY,
5      A SURV,SADULT(2286)
6      IF(TEMAVG(1).LT.68.) GO TO 103
7      FACTK=-1.2919+.02724*TEMAVG(1)
8      GO TO 102
9      103 FACTK=.56
10     C FACTK=1.22-92, 1.00-86, .806-77, .560-68
11     102 DEATHX=1.7724*EXP(-11.4457/(FACTK*L))
12     IF(L.EQ.1) GO TO 101
13     DEATHY=1.7724*EXP(-11.4457/(FACTK*(L-1)))
14     101 SURV =(1.-DEATHX)/(1.-DEATHY)
15     RETURN
16     END

```

```

1      SUBROUTINE CANBAL
2      C THIS SUBROUTINE CALCULATES THE PROBABILITY OF CANNIBALISM OF H. ZEA
3      C LARVAE.
4      COMMON DUM48(3281),EARS(370),DUM49(10747),TOTAL(370,9,2),DUM50(740
5      A2),KK,DUMB(744),KCROP,DUM51,SITES(369),S,DF,DUM52(740),CANLAR,JJ,I
6      B,NN,XPOP,N,PP,DUM54(2),POP,SCANB(425),PRBLAR,PRBNEW
7      C NN EQUAL 1 WHEN CROP IS CORN AND SILKS ARE PRESENT
8      S=SITES(KK)
9      IF(NN.EQ.1)S=EARS(KK )-EARS(KK-15)+1.
10     IF(JJ.EQ.0)GO TO 200
11     C ESTIMATION OF PROEAGILITY OF A LARGER(4-5 INSTAR) LARVAE BEING PRESENT

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12 C ON A FEEDING SITE ON DAY I
13 PRBLAR=TCTAL(1,3,1)/S
14 IF (PRBLAR.GT.1.)PRBLAR=1.
15 ATE=.05+.05*N
16 ATEUP=PRBLAR*FOP*ATE
17 POP=POP-ATEUP
18 XPOP=XPOP+ATEUP
19 IF (I.LT.JJ)RETURN
20 200 IF (POP.LT.1.)GO TO 1
21 F=POP
22 XBAR=POP/S
23 DF=.36
24 PRBNEW=1.-(DF/(DF+XBAR))*DF
25 CANLAR=POP-S*PRBNEW
26 POP=POP-CANLAR
27 4 CONTINUE
28 C ASSUMES THAT ONLY 1 LARGE LARVAE WILL SURVIVE PER SITE
29 PRBNEW=CANLAR/P
30 GO TO 5
31 1 PRBNEW=0.
32 5 IF (PP.LT.1.) GO TO 6
33 PRBLAR=XPOP/PP
34 GO TO 2
35 6 PRBLAR=0.
36 2 CONTINUE
37 RETURN
38 END

```

```

1 SUBROUTINE CROP
2 C THIS SUBROUTINE CALCULATES THE VARIOUS PHENOLOGICAL STAGES, THE
3 C RELATIVE SEARCH AREA, AND NUMBER OF SITES (E.G., EARS) FOR CORN. DEGREE
4 C -DAYS AS DESCRIBED ARE USED TO MAKE THESE CALCULATIONS.
5 COMMON KODE(20),DUM15(1851),ED(370),EDCORN(300),SQUARE(370),BOLLS
6 A(370),EARS(370),HEADS(370),DUM16(374),EGLYTM(370),IFIRST,ILASTC,IB
7 B,IV,DUM17(370),SAREA(370),DUMA(370),ILAST,KRUN,SEXRTD(370,2),
8 CDUM18(2),PCTCRP(5),IGENZ(370,7),DUMI(2590),TEMAVG(370),DUM19(15540
9 D),PRMGRT(370,2),IA,IM,DUM20(4),EGLYPR(370,2),PLANTS,KCROP,IF,SITES
10 E(370),DF,EGLYCR(370,2),DUMMY(7),IN,K,DUMMY2,X,DUMMY3(423),IE
11 DATA A20,A21,A22/-40.6667,83.3333,-41.6667/
12 DATA A30,A31,A32,A33/.2,1.522,-2.8977,1.4394/
13 DATA AM30,AM31,AM32,AM33/.2,1.09554,-1.13822,.19044/
14 DATA AM20,AM21,AM22/-17.5,37.0,-18.5/
15 DATA A40,A41,A42/4.34331,-5.41664,1.6927/
16 KCROP=KODE(11)
17 IF (KCROP.EQ.1) DD=1240
18 IF (KCROP.EQ.2) DD=1390.
19 CDA=205.
20 IF (KCROP.NE.3)GO TO 66
21 CDA=681.
22 DDB=570.
23 COM=1130.
24 C YIELD=1.5
25 C ASSUME 44% LOSS OF SQUARES AND 10% LOSS OF BOLLS
26 YIELD=1.5
27 YIELDS=YIELD*7000000.
28 YELDB=YIELD*7600000.
29 YELDT=400000*YIELD*.8
30 66 CONTINUE
31 IF (KRUN.EQ.0) GO TO 8
32 IF (KODE(14).EQ.0) RETURN
33 8 READ(5,500)IP,IE,IF,IM,PLANTS,NATRA,((PCTCRP(I),I=1,5)
34 500 FORMAT(4I6,F6.0,I6,5F3.2)
35 C IP=PLANTING DATE- IE=EMERGENCE DATE- IE=IP+8 FOR SORGHUM-NATRA(IA)
36 C FOR SORGHUM=191 DEGREE DAYS AFTER IE, MAXIMIN
37 C ATTRACTION FOR SORGHUM BETWEEN BOOT AND MILK STAGE-1735 DEGREE DAYS
38 C AFTER IE OR 1594 DEGREE DAYS AFTER NATRA
39 C ASSUME 105,000 BOLLS/ACRE=18ALE/ACRE
40 C DEGREE DAYS USED FOR HELIOTHIS ZEA IS ALSO USED FOR COTTON.
41 C IE TO IS(1ST SQ)=681.IS TO IB (1ST BOLL) 570.
42 C IB TO IM(1ST OPEN BOLL)=1130.
43 C NATRA=DAY OF FIRST SQUARE
44 IF (KCROP.EQ.3.AND.IP.EQ.0)IP=90
45 IF (IP.EQ.0)IP=75
46 IF (IE.EQ.0)IE=IP+8
47 IF (NATRA.NE.0)GO TO 60
48 IA=IE+1
49 IF (KCROP.EQ.3)GO TO 65
50 IF (IF.NE.0) GO TO 63
51 61 SUM=EDCORN(IA)-EDCORN(IE)
52 IF (SUM.GE.CDA)GO TO 62
53 IA=IA+1
54 GO TO 61

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65 SUM=ED(IA)-ED(IE)
66 IF(SUM.GE.DDB)GO TO 62
67 IA=IA+1
68 GO TO 65
69 63 IA=IF-50
70 DDF=DO*.84
71 67 IF(EDCORN(IF)-EDCORN(IA).GE.DDF)GO TO 62
72 IA=IA-1
73 GO TO 67
74 62 NATRAC=IA
75 60 KFF=IFIRST-1
76 IA=NATRAC
77 SEXRTO(KFF,1)=0.0
78 SEXRTO(KFF,2)=0.0
79 EGLYTM(KFF)=EGLYTM(IFIRST)
80 DO 5 K=KFF,ILAST
81 C ADJUSTES PROBABLE EGG LAY FOR TEMPERATURE
82 X=ABS(75.-EGLYTM(K))
83 IF(X.GT.21.) X=21.
84 IF(X.LT.3.) X=2.
85 P=1.1-.05146*X
86 9 DO 5 IN=IH,IV
87 IF(K.GE.NATRAC)GO TO 110
88 EGLYPR(K,IN)=.1*P
89 EGLYCR(K,IN)=.333
90 X=0.
91 GO TO 111
92 110 GO TO (102,105,103,108,5),KCROP
93 C NATRAC IS DATE CROP BECOMES ATTRACTIVE TO HELIOTHIS
94 C CORN-NATRAC WHEN 6-12 INCHES TALL-1210 DEGREE DAYS
95 C FROM NATRAC TO MAXIMUM SILKING-(50-86 DEGREES)
96 C NATRAC ALSO DATE WHEN SEARCH AREA=1 UNIT
97 102 X=(EDCORN(K)-EDCORN(NATRAC))/DO
98 IF(X.GT.1.60) GO TO 112
99 120 IF(K.GT.ILASTC) GO TO 104
100 IF(KODE(1).NE.3) GO TO 104
101 C REPLACE GO TO 104 WITH GO TO 106 IF TRAP SEX RATIO TO BE USED
102 GO TO 104
103 105 X=(EDCORN(K)-EDCORN(NATRAC))/DO
104 IF(X.GT.1.2)GO TO 112
105 IF(K.GT.ILASTC)GO TO 107
106 IF(KODE(1).NE.3)GO TO 107
107 GO TO 106
108 103 X=(ED(K)-ED(NATRAC))/26
109 IF(K.GT.ILASTC)GO TO 111
110 IF(KODE(1).NE.3.AND.KODE(1).NE.5) GO TO 111
111 106 EGLYCR(K,IN)=(SQRT(SEXRTO(K,IN)))/3.
112 IF(EGLYCR(K,IN).GT.1)EGLYCR(K,IN)=1.0
113 IF(EGLYCR(K,IN).LT..166) EGLYCR(K,IN)=.166
114 EGLYPR(K,IN)=EGLYCR(K,IN)*P
115 GO TO 111
116 C-SEXRTO EQUATIONS NEED TO BE PUT HERE OR CAL. OF EGG LAY PROOF-
117 104 IF(IH.EQ.1.AND.IN.EQ.2)GO TO 2
118 IF(X.GT.1.12) GO TO 2016
119 IF(X.GT..86846)GO TO 2015
120 SEXRTO(K,IN)=A30+(A31+(A32+A33*X)*X)*X
121 GO TO 2019
122 2016 SEXRTO(K,IN)=A40+(A41+A42*X)*X
123 GO TO 2019
124 2015 SEXRTO(K,IN)=A20+(A21+A22*X)*X
125 EGLYCR(K,IN)=SQRT(SEXRTO(K,IN))
126 IF(EGLYCR(K,IN).LT..166) EGLYCR(K,IN)=.166
127 EGLYPR(K,IN)=EGLYCR(K,IN)*P
128 GO TO 111
129 107 IF(IH.EQ.1.AND.IN.EQ.2)GO TO 2
130 IF(X.GT..835)GO TO 2025
131 SEXRTO(K,IN)=AM30+(AM31+(AM32+AM33*X)*X)*X
132 GO TO 2026
133 2025 SEXRTO(K,IN)=AM20+(AM21+AM22*X)*X
134 C REDUCTION OF EGG LAY DUE TO CROP FACTOR (.5 FOR SORGHUM)
135 2026 EGLYCR(K,IN)=SQRT(SEXRTO(K,IN))*5
136 EGLYPR(K,IN)=EGLYCR(K,IN)*P
137 GO TO 111
138 112 EGLYPR(K,IN)=0.
139 EGLYCR(K,IN)=.166
140 GO TO (10,11,12,13),KCROP
141 10 CONTINUE
142 IF(IH.EQ.1.AND.IN.EQ.2) GO TO 2
143 IF(X.LT..84) GO TO 303
144 IF(X.GT.1.16) GO TO 303
145 IM=K
146 TP=(1.-X)*16.66667
147 S=.4*XP(-(TP*TP)/2.)
148 DELTAX=(X-X1)/.06
149 C ASSUME 1 EAR PER PLANT

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140      302 EARS(K)=EARS(K-1)+PLANTS      *S*DEL TAX
141      GO TO 304
142      303 EARS (K)=EARS(K-1)
143      304 X1=X
144      IF(K.LE.NATRAC)GO TO 300
145      IF(X.GT.1)GO TO 301
146      SAREA(K)=X*.5+.1
147      GO TO 33
148      300 SAREA(K)=1.0
149      GO TO 33
150      301 SAREA(K)=SAREA(K-1)
151 C ASSUME 6 SITES PER PLANT AT A SEARCH AREA OF 1
152      33 SITES(K)=SAREA(K)*PLANTS      +EARS(K)
153      IF(KODE(6).EQ.0)GO TO 5
154      CALL MIGRAT
155      GO TO 5
156      11 CONTINUE
157      IF(IH.EQ.1.AND.IN.EQ.2) GO TO 2
158      IF(X.LT..84) GO TO 404
159      IF(X.GT.1.16)GO TO 404
160      IM=K
161      TP=(1.-X)/.04
162      S=.4*EXP(-(TP*TP)/2.)
163      DELTAX=(X-X1)/.04
164      HEADS(K)=HEADS(K-1)+PLANTS*S*DEL TAX
165      GO TO 405
166      404 HEADS(K)=HEADS(K-1)
167      405 X1=X
168      IF(K.LE.NATRAC)GO TO 400
169      IF(X.GT.1)GO TO 401
170      SAREA(K)=X*.5+.1
171      GO TO 43
172      400 SAREA(K)=1.0
173      GO TO 43
174      401 SAREA(K)=SAREA(K-1)
175      43 SITES(K)=SAREA(K)*PLANTS+HEADS(K)
176      IF(KODE(6).EQ.0)GO TO 5
177      CALL MIGRAT
178      GO TO 5
179      12 CONTINUE
180 C IS=FIRST SQUARE, IB = FIRST BOLL, IE=EMERGENCE DATE, IP=PLANTING DATE
181      IM=NATRAC+88
182      IF(IH.EQ.1.AND.IN.EQ.2)GO TO 2
183      IF(K.LT.NATRAC)GO TO 21
184      IF(X.GT.88.)GO TO 22
185      IF(K.EQ.KFF)X1=X-1
186      TP=(40.-X)/13.3
187      S=.4*EXP(-(TP*TP)/2.)
188      DELTAX=(X-X1)/13.3
189      SQUARE(K)=S*DEL TAX*YIELDS
190      GO TO 24
191      22 SQUARE(K)=0.0
192      24 IF(X.LE.21.)GO TO 23
193      TP=(66.-X)/16.
194      S=.4*EXP(-(TP*TP)/2.)
195      DELTAX=(X-X1)/16.
196      BOLLS(K)=S*DEL TAX*YIELDS
197      GO TO 26
198      23 BOLLS(K)=0.0
199      26 SAREA(K)=X/20.+1.0
200      FRUIT=SQUARE(K)+BOLLS(K)
201      27 SITES(K)=SAREA(K)*PLANTS+FRUIT
202      X1=X
203      IF(K.GT.ILASTC) GO TO 28
204      IF(KODE(1).EQ.3.OR.KODE(1).EQ.5) GO TO 5
205 C REDUCTION OF EGG LAY DUE TO CROP FACTOT(.7 FOR COTTON)
206      28 EGLYCR(K,IN)=(FRUIT/YIELDT+.1)*.7
207      EGLYPR(K,IN)=EGLYCR(K,IN)*P
208      GO TO 5
209      21 SQUARE(K)=0.0
210      BOLLS(K)=0.0
211      SAREA(K)=1.0
212      SITES(K)=PLANTS
213      X1=X
214      GO TO 5
215      2 EGLYPR(K,IN)=EGLYPR(K,IN-1)
216      EGLYCR(K,IN)=EGLYCR(K,IN-1)
217      IF(KODE(6).NE.1)GO TO 5
218      CALL MIGRAT
219      GO TO 5
220      108 EGLYCR(K,IN)=.5
221      EGLYPR(K,IN)=.5*P
222      5 CONTINUE
223      13 RETURN
224      END

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1      SUBROUTINE EGGINP
2      C THIS SUBROUTINE HANDLES THE INPUT OF HELIOTHIS POPULATIONS FOR
3      C INITIATING THE MODEL.
4      COMMON KCODE(20),FACTD,DJM1(4744),IFIRST,ILASTC,IH,IV,DUM2(1110),
5      A ILAST,KRUN,SEXRTO(370,2),EGPEMT(2),PCTCRP(5),DUM3(5290),ADTSMG
6      B(370,2,2),TOTAL(370,9,2),SUBEGG(9692)
7      DIMENSION EQELAD(370,2)
8      DIMENSION S(10)
9      IEND=370
10     IF(KRUN.EQ.0) GO TO 20
11     DO 21 I=1,370
12     DO 21 J=IH,IV
13     EQELAD(I,J)=0.
14     21 TOTAL(I,7,J)=0.0
15     IF(KODE(6).EQ.2) GO TO 22
16     20 CONTINUE
17     L=KODE(1)
18     X=1.
19     IF(L.EQ.4)X=.31
20     IF(L.EQ.6)X=.31
21     GO TO (1,2,3,2,22,30,30),L
22     C READS IN MOTHS TOTAL NO. BOTH SEXES COMBINED
23     DO 19 J=IFIRST,ILASTC
24     11 READ(11,502)I,BMALE,BFMALE,CMALE,CFMALE
25     IF(I.NE.J) GO TO 11
26     TOTAL(I,7,1)=(BMALE+BFMALE)
27     TOTAL(I,7,2)=(CMALE+CFMALE)
28     19 CONTINUE
29     GO TO 5
30     C READS IN 0-1 DAY CLD EGGS/ACRE
31     DO 29 J=IFIRST,ILASTC
32     12 READ(11,501)I,B,C
33     501 FORMAT(9X,I3,2F6.0)
34     IF(I.NE.J) GO TO 12
35     IF(L.EQ.4)I=I-2
36     TOTAL(I,7,1)=(B/EGPEMT(1))*X
37     TOTAL(I,7,2)=(C/EGPEMT(2))*X
38     29 CONTINUE
39     GO TO 5
40     C READS IN MOTHS SEX SEPARATELY
41     DO 39 J=IFIRST,ILASTC
42     13 READ(11,502)I,BMALE,BFMALE,CMALE,CFMALE
43     502 FORMAT(16,4F6.1)
44     IF(I.NE.J) GO TO 13
45     TOTAL(I,7,1)=BMALE *2.
46     TOTAL(I,7,2)=CMALE *2.
47     SEXRTO(I,1)=(BMALE+1.0)/(BFMALE+1.0)
48     SEXRTO(I,2)=(CMALE+1.0)/(CFMALE+1.0)
49     39 CONTINUE
50     GO TO 5
51     30 ILASTC=1
52     IFIRST=365
53     READ(11,504)B,C,I
54     504 FORMAT(18X,2F6.0,5X,I3)
55     IF(I.EQ.0)GO TO 5
56     IF(L.EQ.6)I=I-2
57     TOTAL(I,7,1)=(B*X)/EGPEMT(1)
58     TOTAL(I,7,2)=(C*X)/EGPEMT(2)
59     IF(IFIRST.GT.I)IFIRST=I
60     IL=ILASTC
61     IF(ILASTC.LT.I)ILASTC=I
62     IF(IFIRST.EQ.ILASTC)GO TO 31
63     IDD=ILASTC-IL
64     IF(IDD.EQ.1)GO TO 31
65     XDL1=TOTAL(ILASTC,7,1)-TOTAL(IL,7,1)
66     XDL2=TOTAL(ILASTC,7,2)-TOTAL(IL,7,2)
67     XDL1=XDL1/IDD
68     XDL2=XDL2/IDD
69     IDD=IDD-1
70     DO 32 J=1,IDD
71     TOTAL(IL+J,7,1)=TOTAL(IL,7,1)+XDL1*J
72     TOTAL(IL+J,7,2)=TOTAL(IL,7,2)+XDL2*J
73     32 CONTINUE
74     GO TO 30
75     31 IL=ILASTC
76     GO TO 30
77     22 DO 24 I=IFIRST,ILAST
78     DO 24 IN=IH,IV
79     IF(IN.EQ.2) GO TO 27
80     DO 28 J=1,2
81     C MOTHS EMERGING FROM CORN LAY 3 TIMES AS MANY EGGS AS MOTHS EMERGING
82     C FROM SORGHUM.
83     XEGG=1.0
84     IF(J.EQ.2)XEGG=.333
85     TOTAL(I,7,IN)=(ADTSMG(I,J,IN)*PCTCRP(J)/PCTCRP(KODE(11)))*XEGG+TOT

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86      2AL(I,7,IN)
87      28 CONTINUE
88      GO TO 24
89      IF(I.GT.ILASTC) GO TO 24
90      26 READ(11,503)K,CMALE,CFMALE
91      503 FORMAT(16,12X,2F6.1)
92      IF(K.NE.1) GO TO 26
93      TOTAL(I,7,IN)=CMALE*2.
94      24 CONTINUE
95      5 CONTINUE
96      RETURN
97      END

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1      SUBROUTINE FLDPOP
2      C THIS SUBROUTINE CONVERTS LIGHT TRAP CATCHES TO FIELD POPULATION(MOTHS
3      C /ACRE)AS DESCRIBED BY HARTSTACK ET AL (1971) AND HARTSTACK AND
4      C HOLLINGSWORTH (1974). THE LIGHT TRAP CATCHES ARE ADJUSTED FOR LOW
5      C NIGHT TEMPERATURE ALSO.
6      REAL NITMIN
7      COMMON KODE(20),FACTD,DUM37(1480),NITMIN(370),DUM38(2524),EGLYTM(3
8      A70),IFIRST,ILASTC,IH,IV,ADMOON(370),DUM39(9259),TOTAL(370,9,2),
9      BDUM(9267),IN,DUMP(3),IPX,SFLP(420)
10     DATA E,9,FD/.428,98.8,10560./
11     C TRAP FACTORS FOR 40 WATT BLACKLIGHT TRAP.
12     IF (KODE(9).EQ.2)RETURN
13     C=2.*3.1416*E**2.*E*(ALOG((FD+R)/R)-(FD/(FD+R)))
14     FACTD=43560./C
15     C NEW TRAP DESIGN REDUCES CATCH BY 30 PERCENT IF CENTER CYLINDER IS
16     C NOT COUNTED.
17     FACTD=FACTD*.70
18     C ADJUSTMENT OF TRAP CATCH FOR REDUCTION OF CATCH BY LOW TEMPERATURES.
19     IHH=IH
20     IF(KODE(1).EQ.7) IHH=2
21     DO 100 IDY=IFIRST,ILASTC
22     DO 100 IN=IHH,IV
23     IF(IDY.GE.154) GO TO 102
24     F=136.9-.86667*IDY
25     A1=312.4-5.9*IDY
26     A2=-23.6753+.20281*IDY
27     A3=.252667-.001762*IDY
28     TEMP=NITMIN(IDY)
29     IF(TEMP.LT.55.) TEMP=55.
30     F1=A1+(A2+A3*TEMP)*TEMP
31     TRAPIN=FACTD*F/F1
32     IF(TEMPIN.LT.FACTD)TRAPIN=FACTD
33     GO TO 103
34     102 TRAPIN=FACTD
35     103 TOTAL(IDY,7,IN)=(TOTAL(IDY,7,IN)*TRAPIN)
36     100 CONTINUE
37     IF(KODE(8).EQ.0) RETURN
38     C IF ACTUAL TRAP CATCHES ARE USED-SUBROUTINE SMOOTH IS CALLED AND
39     C CATCHES ARE SMOOTHED BY A DOUBLE 3 DAY MOVING AVERAGE.
40     DO 101 I=IHH,IV
41     IPX=12
42     IN=1
43     IF(I.EQ.2)IN=10
44     CALL SMOOTH
45     101 CONTINUE
46     RETURN
47     END

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1      SUBROUTINE GENLN
2      C THIS SUBROUTINE CALCULATES THE NUMBER OF DAYS REQUIRED FOR
3      C DEVELOPMENT OF VARIOUS INSECT STAGES ALONG WITH EXPECTED DEVIATIONS
4      C FROM MEAN DEVELOPMENT TIME.
5      COMMON KODE(20),DUM9,SDEV(370,4),DUM10(370),ED(370),DUM11(2524),
6      QIFIRST,DUM12,IH,IV,DUM13(1110),ILAST,KRUN,DUM14(747),IGEN(370,14),
7      WTEMAVG(370),SGENLN(18572)
8      DIMENSION DEGDAY(6,2),A1(4),A2(4),A3(4)
9      DIMENSION JS(4),P(6)
10     DIMENSION F(4)
11     DATA A1/3*9.35,6.41/,A2/3*-.2235,-.1555/,A3/3*.00135,.00095/
12     DATA F/1.0,1.73,1.73,1.41/
13     DATA IKODE/0/
14     5 IF(KODE(11).EQ.1KODE) RETURN
15     C REMOVE NEXT CARD (IF(KRUN.NE.0)RETURN) IF DEVELOPMENT TIME IS TO
16     C BE CHANGED.
17     IF(KRUN.NE.0) RETURN
18     IF(KODE(11).EQ.2.AND.IKODE.EQ.1) RETURN

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19      IF(KODE(11).EQ.1.AND.IKODE.EQ.2) RETURN
20      IKODE=KODE(11)
21      GO TO (1,1,2,1),IKODE
22      2 CONTINUE
23      1 DEGDAY(1,1)=72.9
24      DEGDAY(1,2)=69.
25      DEGDAY(2,1)=156.8
26      DEGDAY(2,2)=156.8
27      DEGDAY(3,1)=216.5
28      DEGDAY(3,2)=216.5
29      DEGDAY(4,1)=323.1
30      DEGDAY(4,2)=323.1
31      DEGDAY(5,1)=1000.0
32      DEGDAY(5,2)=1000.0
33      3 CONTINUE
34      IN=7*(IH-1)
35      EDICK=ED(IFIRST-1)
36      DO 100 I=IFIRST,ILAST
37      IGENX=0
38      DO 104 L=1,4
39      J=L+IN
40      SDEV(I,L)=0.0
41      DO 101 K=I,365
42      X=A1(L)+(A2(L)+A3(L)*TEMAVG(I))*TEMAVG(I)
43      SDEV(I,L)=SDEV(I,L)+X*X
44      IF(ED(K)-EDICK.LT.DEGDAY(L,IH)) GO TO 101
45      IX=K-I+1
46      IGENX=IGENX+IX
47      IGEN(I,J)=IX
48      SDEV(I,L)=SQRT(SDEV(I,L)/IX)*F(L)
49      GO TO 104
50      101 CONTINUE
51      104 CONTINUE
52      IGEN(I,IN+5)=(5327.35*TEMAVG(I)**(-1.8238))+.6
53      IGEN(I,IN+7)=IGENX+IGEN(I,IN+5)
54      IGEN(I,IN+6)=28.25-.24037*TEMAVG(I)
55      EDICK=ED(I)
56      100 CONTINUE
57      IF(IH.EQ.2) RETURN
58      IF(IV.EQ.1) RETURN
59      DO 202 I=1,4
60      P(I)=DEGDAY(I,2)/DEGDAY(I,1)
61      DO 200 K=IFIRST,ILAST
62      DO 203 I=1,4
63      J=I+7
64      IGEN(K,J)=IGEN(K,I)*P(I)+.5
65      203 CONTINUE
66      DO 201 I=5,7
67      J=I+7
68      IGEN(K,J)=IGEN(K,I)
69      201 CONTINUE
70      200 CONTINUE
71      RETURN
72      END

```

```

1      SUBROUTINE GRAPH
2      C THE USE OF THIS SUBROUTINE IS OPTIONAL DEPENDING ON THE NEED FOR A
3      C GRAPH OF THE OUTPUT AND OR INPUT OF THE MODEL.
4      COMMON KODE(20),DUM66(4001),S(4),DUM67(740),IFIRST,DUM68(1113),
5      AILAST,DUM69(6298),EQELAD(370,2),DUM70(1480),TOTAL(370,9,2),DUM71
6      B(9272),IKODE(12,3),DATX(370),SGRAPH(14)
7      DIMENSION SCALE(5)
8      INTEGER VFA(5)/('1H','I4','X,I1',) //
9      INTEGER VFB(5)/('1H+','4X','X,I1',) //
10     INTEGER DIGIT(127),DIGIT1(70),DIGIT2(57)
11     EQUIVALENCE(DIGIT(1),DIGIT1(1)),(DIGIT(71),DIGIT2(1))
12     DATA DIGIT1 /'1','2','3','4','5','6','7','8','9','10','11',
13     X'12','13','14','15','16','17','18','19','20','21','22','23','24',
14     X'25','26','27','28','29','30','31','32','33','34','35','36','37',
15     X'38','39','40','41','42','43','44','45','46','47','48','49','50',
16     X'51','52','53','54','55','56','57','58','59','60','61','62','63',
17     X'64','65','66','67','68','69','70'/
18     DATA DIGIT2 /'71','72','73','74','75','76','77','78','79',
19     X'80','81','82','83','84','85','86','87','88','89','90','91',
20     X'92','93','94','95','96','97','98','99','100','101','102','103',
21     X'104','105','106','107','108','109','110','111','112','113',
22     X'114','115','116','117','118','119','120','121','122','123',
23     X'124','125','126','127'
24     DIMENSION INSECT(3),ISTAGE(10)
25     DATA INSECT/'-ZEA','-VIR','-Z+V'/
26     DATA ISTAGE/'EGGS','SLAR','LLAR','PUPA','POAD','OPAD','INPT',
27     'INMG','PAEG','EQOA'/
28     DIMENSION SS(2)

```



```

29      SXZ=0.
30      SXV=0.
31      SXZV=0.
32      N=1
33      WRITE(1,611)
34      611 FORMAT('1')
35      NSCALE=0
36      ISTG=1
37      KSTG=4
38      24 DO 2020 IS=ISTG,KSTG
39      DO 2020 IN=1,3
40      IF(IGKODE(IS,IN).EQ.0)GO TO 2020
41      IF(IN.EQ.1)SXZ=1
42      IF(IN.EQ.2)SXV=1
43      IF(IN.EQ.3)SXZV=1
44      WRITE(1,610)N,ISTAGE(IS),INSECT(IN)
45      610 FORMAT(' ',20X,I1,' = ',A4,A4)
46      N=N+1
47      2020 CONTINUE
48      IF(IS.GT.6)GO TO 25
49      ISTG=9
50      KSTG=9
51      GO TO 24
52      25 CONTINUE
53      NN=N
54      IF(N.EQ.1)GO TO 2021
55      IF(KODE(16).GE.100)GO TO 2024
56      WRITE(1,600)
57      600 FORMAT(' LOG SCALE PLOT')
58      WRITE(1,604)
59      604 FORMAT(' ',3X,'100.0',25X,'1000.0',25X,'10000.0',23X,'100000.0'
60      V23X,'1000000.0')
61      GO TO 2021
62      2024 WRITE(1,603)
63      603 FORMAT(' LINEAR SCALE PLOT')
64      13 IF(SXZ.EQ.1.AND.SXV.EQ.1.AND.SXZV.NE.1)GO TO 10
65      IF(SXZV.EQ.1)GO TO 11
66      IF(SXZ.EQ.1)SX1=S(1+NSCALE)
67      IF(SXV.EQ.1)SX1=S(2+NSCALE)
68      GO TO 12
69      10 SX1=S(1+NSCALE)
70      IF(S(2+NSCALE).GT.S(1+NSCALE))SX1=S(2+NSCALE)
71      GO TO 12
72      11 SX1=S(1+NSCALE)+S(2+NSCALE)
73      12 SCALE(1)=0.0
74      DO 101 I=2,5
75      101 SCALE(I)=SCALE(I-1)+SX1/4.
76      WRITE(1,606)(SCALE(I),I=1,5)
77      606 FORMAT(' ',F6.0,2(F31.0,F32.0))
78      IF(NSCALE.EQ.0)SS(1)=SX1/127.
79      IF(NSCALE.EQ.2)SS(2)=SX1/127.
80      IF(NSCALE.EQ.2)GO TO 2023
81      2021 ISTG=5
82      KSTG=8
83      27 DO 2022 IS=ISTG,KSTG
84      DO 2022 IN=1,3
85      IF(IGKODE(IS,IN).EQ.0)GO TO 2022
86      IF(IN.EQ.1)SXZ=1
87      IF(IN.EQ.2)SXV=1
88      IF(IN.EQ.3)SXZV=1
89      WRITE(1,610)N,ISTAGE(IS),INSECT(IN)
90      N=N+1
91      2022 CONTINUE
92      IF(IS.GT.9)GO TO 26
93      ISTG=10
94      KSTG=10
95      GO TO 27
96      26 CONTINUE
97      IF(N.EQ.NN)GO TO 2023
98      IF(KODE(16).GE.100)GO TO 2025
99      WRITE(1,600)
100     WRITE(1,605)
101     605 FORMAT(' ',5X,'1.0',27X,'10.0',27X,'100.0',25X,'1000.0',25X,
102     N'10000.0')
103     GO TO 2023
104     2025 WRITE(1,603)
105     NSCALE=2
106     GO TO 13
107     2023 IF(KODE(16).LT.100)GO TO 3000
108     DO 3001 J=IFIRST,ILAST
109     WRITE(1,601)J
110     601 FORMAT(' ',I4,' ',30X,' ',31X,' ',30X,' ',31X,' ')
111     N=1
112     DO 3002 I=1,12
113     DO 3002 IN=1,3

```

```

114      IF(IGKODE(I,IN).EQ.0)GO TO 3002
115      IF(IN.EQ.3)GO TO 3003
116      GO TO (4,4,4,4,5,5,5,5,4,6,3004,3005),I
117      5 K=TOTAL(J,I,IN)/SS(2)+1.
118      GO TO 302
119      4 K=TOTAL(J,I,IN)/SS(1)+1.
120      GO TO 302
121      6 K=EQELAD(J,IN)/SS(2)+1.
122      GO TO 302
123      3005 K=DATX(J)/SS(2)+1.
124      GO TO 302
125      3004 K=DATX(J)/SS(1)+1.
126      GO TO 302
127      3003 GO TO (7,7,7,7,8,8,8,8,7,9,3004,3005),I
128      7 K=(TOTAL(J,I,1)+TOTAL(J,I,2))/SS(1)+1.
129      GO TO 302
130      8 K=(TOTAL(J,I,1)+TOTAL(J,I,2))/SS(2)+1.
131      GO TO 302
132      9 K=(EQELAD(J,1)+EQELAD(J,2))/SS(2)+1.
133      302 IF(K.GT.127) K=127
134      VFB(3)=DIGIT(K)
135      WRITE(1,VFB)N
136      N=N+1
137      3002 CONTINUE
138      3001 CONTINUE
139      GO TO 5000
140      3000 DO 4000 J=IFIRST,ILAST
141      WRITE(1,601)J
142      N=1
143      DO 4002 I=1,10
144      DO 4002 IN=1,3
145      IF(IGKODE(I,IN).EQ.0)GO TO 4002
146      IF(IN.EQ.3) GO TO 4003
147      GO TO (14,14,14,14,15,15,15,15,14,16),I
148      14 B=TOTAL(J,I,IN)/100.
149      GO TO 207
150      15 B=TOTAL(J,I,IN)
151      GO TO 207
152      16 B=EQELAD(J,IN)
153      GO TO 207
154      4003 GO TO (17,17,17,17,18,18,18,18,17,19),I
155      17 B=(TOTAL(J,I,1)+TOTAL(J,I,2))/100.
156      GO TO 207
157      18 B=(TOTAL(J,I,1)+TOTAL(J,I,2))
158      GO TO 207
159      19 B=EQELAD(J,1)+EQELAD(J,2)
160      207 IF(B.LT.1.1)GO TO 203
161      K=(ALOG10(B)/4.)*127
162      IF(K.GT.127)K=127
163      205 VFB(3)=DIGIT(K)
164      WRITE(1,VFB)N
165      GO TO 208
166      203 K=1
167      GO TO 205
168      208 CONTINUE
169      N=N+1
170      GO TO 4002
171      4002 CONTINUE
172      4000 CONTINUE
173      5000 CONTINUE
174      RETURN
175      END

```

```

1      SUBROUTINE MIGRAT
2      C THIS SUBROUTINE CALCULATES THE PROBABILITY OF MOTHS MIGRATING AWAY
3      C FROM A PARTICULAR CROP.
4      COMMON KODE(20),DUM55(27698),PRMGRT(370,2),DUM56(747),XCROP,DUM57(
5      A1119),IN,K,DUM58,X,SMIGRA(421)
6      DIMENSION PCTMG(2)
7      DATA PCTMG(1)/.6/,PCTMG(2)/.6/
8      DATA XM/1.10/,XD/1.45/
9      IF(KODE(15).EQ.0) RETURN
10     PRMGRT(K,IN)=0.0
11     IF(X.LE.XM)RETURN
12     IF(X.GE.XD)GO TO 1
13     PRMGRT(K,IN)=((X-XM)/(XD-XM))*PCTMG(IN)
14     RETURN
15     1 PRMGRT (K,IN)=PCTMG(IN)
16     RETURN
17     END

```

```

1      SUBROUTINE MOON
2      C FOR EACH SIMULATION DAY THIS SUBROUTINE CALCULATES THE NUMBER OF
3      C DAYS FROM FULL MOON, WHICH IS USED TO SELECT THE PROPER MOONLIGHT
4      C ADJUSTMENT FACTOR FOR OVIPOSITION.
5      COMMON KODE(20),DUM31(4749),ADMOON(370),DUM32(370),TCLCUD(370),
6      ZSMOON(24871)
7      DIMENSION FM(29)
8      DATA FM/1.,1.,.99,.99,.98,.97,.94,.91,.86,.82,.73,.61,.45,.24,.24,
9      2.53,.75,.89,.96,10*1./
10     A=KODE(3)
11     IF(A.GT.15.) A=A-29.5
12     A=A-15.
13     DO100 I=1,365
14     R=1
15     J=9-A
16     IF(J.LT.30)GOTO 4
17     A=A+29.5
18     J=1
19     4 CONTINUE
20     ADMOON(I)=FM(J)+(1.-FM(J))*TCLCUD(I)
21     100 CONTINUE
22     RETURN
23     END

1      SUBROUTINE PARINP
2      C THIS SUBROUTINE CALCULATES PARASITISM OF EGGS AND LARVAE AS DESCRIBED
3      C IN TEXT
4      COMMON KODE(20),DUM21(4745),IFIRST,DUM22(373),SAREA(370),DUM23(370
5      A),ILAST,KRUN,DUM24(20357),PARSIT(370,2),DUM25(1480),IA,IM,SPAR(229
6      40)
7      DIMENSION PA(2)
8      IF(KRUN.EQ.0) GO TO 10
9      DO 11 I=IFIRST,ILAST
10     DO 11 J=1,2
11     11 PARSIT(I,J)=0.0
12     12 L=KODE(5)
13     C IF KODE 5 = 4 READ PA(1) = 0
14     GO TO (1,2,3,1),L
15     1 PMIN1=IA
16     PMAX1=IA+20
17     PMIN2=IA+20
18     PMAX2=IM-20
19     PDOWN=IM
20     PEND=IM+25
21     READ(5,500) PA(1),PA(2)
22     500 FORMAT(2F6.3)
23     DO 4 I=IFIRST,ILAST
24     IF(I.LE.PMIN1.OR.I.GE.PEND) GO TO 4
25     IF(KODE(11).EQ.3) GO TO 44
26     IF(I.GE.PMAX1) GO TO 7
27     FX=((I-PMIN1)/(PMAX1-PMIN1))*5
28     GO TO 6
29     7 IF(I.GT.PMIN2) GO TO 8
30     FX=.5
31     GO TO 6
32     8 IF(I.GE.PMAX2) GO TO 9
33     FX=.5+((I-PMIN2)/(PMAX2-PMIN2))*5
34     GO TO 6
35     9 IF(I.GT.PDOWN) GO TO 99
36     FX=1.0
37     GO TO 6
38     99 FX=(PEND-I)/(PEND-PDOWN)
39     GO TO 6
40     44 IF(I.GE.PMAX1) GO TO 45
41     FX=(I-PMIN1)/(PMAX1-PMIN1)
42     GO TO 6
43     45 IF(I.GT.PMAX2) GO TO 46
44     GO TO 98
45     46 FX=(PEND-1)/(PEND-PMAX2)
46     6 PARSIT(I,1)=PA(1)*FX
47     PARSIT(I,2)=PA(2)*FX
48     4 CONTINUE
49     IF(L.EQ.4)GO TO 12
50     GO TO 5
51     2 READ(13,501,END=5)I,TRICH,OTHERS,OLARPA
52     501 FORMAT(I6,3F6.0)
53     IF(I.EQ.0) GO TO 5
54     C EGG PARASITISM
55     N=45769
56     B=-.693/(N*SAREA(I))
57     PTRICH=1.-(EXP(TRICH*B))
58     N=5000
59     B=-.693/(N*SAREA(I))
60     POTHERS=1.-(EXP(OTHERS*B))

```

```

61      PARSIT(I,1)=1.-((1.-PTRICH)*(1.-POTHR5))
62      C 1-3 INSTAR LARVAE PARASITIZM
63      N=300
64      R=-.693/(N*SAREA(I))
65      POTHR5=1.- (EXP(OLARPA#R))
66      PARSIT(I,2)=POTHR5
67      GO TO 2
68      3 READ (13,502,END=5) I,X,Y
69      502 FORMAT(16,2F6.3)
70      IF(I.EQ.0) GO TO 5
71      PARSIT(I,1)=X
72      PARSIT(I,2)=Y
73      GO TO 3
74      12 READ(13,501,END=5) I,TRICH
75      IF(I.EQ.0) GO TO 5
76      PARSIT(I,1)=TRICH
77      GO TO 12
78      5 RETURN
79      END

```

```

1      SUBROUTINE PRDINP
2      C THIS SUBROUTINE CALCULATES PREDATION OF EGGS AND LARVAE AS DESCRIBED
3      C IN TEXT.
4      COMMON KODE(20),DUM26(4745),IFIRST,DUM27(373),SAREA(370),DUM28(370
5      A),ILAST,KRUN,DUM29(21097),PREDOR(370,2),DUM30(740),IA,IM,SPRD(2290
6      B)
7      DIMENSION PA(2)
8      DIMENSION PDORTE(7),PDLRTE(7),PRED(7)
9      DATA PDORTE/1.25,1.5,.25,.5,1.0,.75,1.75/
10     DATA PDLRTE/.5,1.0,.25,.75,1.25,1.75,1.50/
11     C PDLRTE=PREDATOR RATING FOR LARVAE
12     C PDORTE=PREDATOR RATING FOR EGGS
13     C 1=SEYMINUS,2=OTHER COCCINELLIDAE,3=OTHERCOLEOPTERA,
14     C 4= ORIOUS,5=GEOCORIS,6=OTHER HEMIPTERA,7=CHRYSOPAIMMATURES
15     IF(KRUN.EQ.0) GO TO 10
16     DO 11 I=IFIRST,ILAST
17     DO 11 J=1,2
18     11 PREDOR(I,J)=0.0
19     10 L=KODE(12)
20     FX=1.0
21     GO TO (1,2,3,30),L
22     1 FMIN1=IA
23     FMAX1=IA+20
24     PMIN2=IA+20
25     PMAX2=IM-20
26     PDOWN=IM
27     PEND=IM+25
28     READ(5,500) PA(1),PA(2)
29     500 FORMAT(3F6.3)
30     DO 4 I=IFIRST,ILAST
31     IF(I.LE.PMIN1.OR.I.GE.PEND) GO TO 4
32     IF(KODE(11).EQ.3) GO TO 44
33     IF(I.GE.PMAX1) GO TO 7
34     FX=((I-PMIN1)/(PMAX1-PMIN1))*5
35     GO TO 6
36     7 IF(I.GT.PMIN2) GO TO 8
37     FX=.5
38     GO TO 6
39     8 IF(I.GE.PMAX2) GO TO 9
40     FX=.5+((I-PMIN2)/(PMAX2-PMIN2))*5
41     GO TO 6
42     9 IF(I.GT.PDOWN) GO TO 99
43     FX=1.0
44     GO TO 6
45     99 FX=(PEND-I)/(PEND-PDOWN)
46     GO TO 6
47     44 IF(I.GE.PMAX1) GO TO 45
48     FX=(I-PMIN1)/(PMAX1-PMIN1)
49     GO TO 6
50     45 IF(I.GT.PMAX2) GO TO 46
51     GO TO 6
52     46 FX=(PEND-I)/(PEND-PMAX2)
53     6 PREDOR(I,1)=PA(1)*FX
54     PREDOR(I,2)=PA(2)*FX
55     4 CONTINUE
56     GO TO 5
57     2 READ(14,501,END=5) I,(PRED(J),J=1,7),SPID,CHRYSP
58     501 FORMAT(9X,I3,6F6.0,6X,2F6.0,6X,F6.0)
59     IF(I.EQ.0) GO TO 5
60     NTHEGG=0.0

```

```

61      OTHLAR=0.0
62      DO 20 K=1,7
63      OTHEGG=OTHEGG+PRED(K)*PDERT(K)
64      OTHLAR=OTHLAR+PRED(K)*PDLRTE(K)
65      CONTINUE
66      C EGG PREDATION
67      N=44827
68      B=-.693/(N*SAREA(I))
69      PCHRS=1.-(EXP(CHRYSP*B))
70      N=14368
71      B=-.693/(N*SAREA(I))
72      POTHR=1.-(EXP(OTHEGG*B))
73      PRDOR(I,1)=1.-(1.-PCHRS)*(1.-POTHR)
74      C 1-3 INSTAR LARVAE PREDATION
75      N=13051
76      B=-.693/(N*SAPFA(I))
77      PCHRS=1.-(EXP(CHRYSP*B))
78      N=8929
79      B=-.693/(N*SAREA(I))
80      POTHR=1.-(EXP(OTHLAR*B))
81      PRDOR(I,2)=1.-(1.-PCHRS)*(1.-POTHR)
82      GO TO 2
83      3 READ(14,502,END=5) I,X,Y,Z
84      502 FORMAT(I6,3F6.3)
85      IF(I.EQ.0) GO TO 5
86      PRDOR(I,1)=X
87      PRDOR(I,2)=Y
88      GO TO 3
89      30 IFF=365
90      ILL=1
91      31 READ(14,503,END=34) SP,ALB,HEMP,CHL,CHA,CALLOP,I
92      503 FORMAT(6X,6F5.0,I3)
93      IF(I.EQ.0) GO TO 34
94      PRDOR(I,1)=ALB*1.5+HEMP*1.0+CHL*1.75+CHA+CALLOP
95      PRDOR(I,2)=ALB+HEMP*1.25+CHL*1.5+CHA+CALLOP
96      IF(IFF.GT.1) IFF=I
97      IL=ILL
98      IF(ILL.LT.1) ILL=1
99      IF(IFF.EQ.ILL) GO TO 32
100     IDD=ILL-1
101     IF(IDD.EQ.1) GO TO 32
102     XDL1=PRDOR(ILL,1)-PRDOR(IL,1)
103     XDL2=PRDOR(ILL,2)-PRDOR(IL,2)
104     XDL1=XDL1/IDD
105     XDL2=XDL2/IDD
106     IDD=IDD-1
107     DO 33 J=1,IDD
108     PRDOR(IL+J,1)=PRDOR(IL,1)+XDL1*J
109     PRDOR(IL+J,2)=PRDOR(IL,2)+XDL2*J
110     33 CONTINUE
111     GO TO 31
112     32 IL=ILL
113     GO TO 31
114     34 NF=14368
115     NL=8929
116     DO 35 J=IFF,ILL
117     B=-.693/(NF*SAREA(J))
118     PRDOR(J,1)=1.-(EXP(PREDOR(J,1)*B))
119     B=-.693/(NL*SAREA(J))
120     PRDOR(J,2)=1.-(EXP(PREDOR(J,2)*B))
121     35 CONTINUE
122     5 RETURN
123     END

```

```

1      SUBROUTINE SMOOTH
2      C THIS SUBROUTINE WHEN CALLED APPLIES A DOUBLE 3-DAY MOVING AVERAGE
3      C TO INSECT POPULATION DATA.
4      COMMON DUM62(4765),IXF,IXL,DUM63(7411),SM(370,24),DUM64(9267),IN,
5      ADUM65(3),IPX,SSMOO(420)
6      C IXF-FIRST DAY OF SMOOTH IXL-LAST DAY OF SMOOTH IP-STAGE IN- INSECT
7      DIMENSION S(5)
8      IP=IPX+IN
9      DO 100 I=3,5
10     S(I)=0.0
11     IXXF=IXF+2
12     S(1)=SM(IXF+1,IP)
13     S(2)=SM(IXF,IP)
14     DO 101 I=IXXF,IXL
15     K=0
16     DO 102 J=2,5
17     S(5-K)=S(4-K)

```

```

18 102 K=K+1
19 S(1)=SM(I,IP)
20 SM(I-2,IP)=(S(5)+2.*S(4)+3.*S(3)+2.*S(2)+S(1))/9.
21 101 CONTINUE
22 SM(IXL-1,IP)=(S(4)+2.*S(3)+3.*S(2)+2.*S(1))/8.
23 SM(IXL,IP)=(S(3)+2.*S(2)+3.*S(1))/6.
24 RETURN
25 END

```

```

1 SUBROUTINE SPRAY
2 C READS IN INSECTICIDE MORTALITIES-J-1THRU12
3 C THIS SUBROUTINE HANDLES ALL INPUT OF MORTALITIES CAUSED BY
4 C INSECTICIDES.
5 COMMON KODE(20),DUM33(4745),IFIRST,DUM34,IH,IV,DUM35(1110),ILAST,
6 AKRUN,DUM36(15177),POS(370,7,2),SSPRAY(4512)
7 DIMENSION P(7,2)
8 IF(KODE(4).EQ.2) RETURN
9 IF(KODE(4).EQ.0.AND.KRUN.EQ.0)RETURN
10 DO 2 J=1,7
11 DO 2 I=IFIRST,ILAST
12 DO 2 IN=IH,IV
13 2 POS(I,J,IN)=0.0
14 IF(KODE(4).EQ.0)RETURN
15 100 READ(12,500,END=5)I,((P(J,IN),J=1,7),IN=IH,IV)
16 500 FORMAT(I6,14F4.3)
17 IF(I.EQ.0)RETURN
18 DO 101 IN=IH,IV
19 DO 101 J=1,7
20 101 POS(I,J,IN)=P(J,IN)
21 GO TO 100
22 5 RETURN
23 END

```

```

1 SUBROUTINE TEMP
2 C ALL OF THE TEMPERATURE AND CLOUD COVER INPUT AND THE CALCULATION OF
3 C DAYS ARE HANDLED BY TEMP.
4 REAL NITMIN
5 COMMON KODE(20),DUM5(1481),NITMIN(370),ED(370),EDCORN(300),DUM6
6 A(1854),EGLYTM(370),IFIPST,DUM7(743),TCLCUD(370),ILAST,DUM8(5928),
7 BTEMVAVG(370),STEMP(18572),IFISTT,ILASTT
8 DIMENSION CLOUD(24)
9 DIMENSION TMFA(800)
10 DIMENSION TM(24)
11 KKK=KODE(2)
12 KK=KODE(19)
13 ED(IFISTT-1)=0.0
14 EDCORN(IFISTT-1)=0.0
15 ET=54.7
16 T1=50.
17 T2=86.
18 TD=T2-T1
19 503 FORMAT(13,2F3.0)
20 DO 304 IDY=IFISTT,ILASTT
21 IF(KKK.NE.3) GO TO 200
22 IF(IDY.EQ.1FISTT) GO TO 404
23 GO TO 410
24 800 KRUN=0
25 200 READ(15,502,END=402) I,(TM(J),J=1,24)
26 502 FORMAT(2X,I3,3X,24F3.0)
27 IF(I.NE.IDY) GO TO 200
28 M=I
29 GO TO 400
30 402 CONTINUE
31 WRITE(6,1000) IFISTT,M
32 1000 FORMAT(11,'HOURLY TEMPERATURE INPUT FROM DAYS ',I3,' TO ',I3)
33 404 READ(16,503) I,THP,TLP
34 IF(I.NE.IDY) GO TO 404
35 WRITE(6,2000) IDY,ILASTT
36 2000 FORMAT(11,'MAX/MIN TEMPERATURE INPUT FROM DAYS ',I3,' TO ',I3/)
37 KKK=3
38 410 CONTINUE
39 THQ=THP
40 TLO=TLP
41 READ(16,503) I,THP,TLP
42 TAO=(THQ+TLO)/2.
43 TPO=(THQ-TLO)/2.
44 TAM=(THQ+TLP)/2.
45 TPM=(THQ-TLP)/2.
46 TM(1)=TAO+TPO*(-.96593)
47 DO 417 J=2,14

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48      TM(J)=TAD+TPD* $\cos(.2618*(14-J))$ 
49      417 CONTINUE
50      DO 419 J=15,24
51      TM(J)=TAM+TPM* $\cos(.2618*(J-14))$ 
52      419 CONTINUE
53      499 IF(KK.EQ.0) GO TO 305
54      201 READ(17,504,END=306) I,(CLOUD(J),J=1,24)
55      504 FORMAT(2X,I3,3X,24F3.1)
56      IF(1.NF.IDY) GO TO 201
57      GO TO 305
58      306 CONTINUE
59      KK=0
60      305 CONTINUE
61      213 ED(IDY)=ED(IDY-1)
62      EDCORN(IDY)=EDCORN(IDY-1)
63      TEMAVG(IDY)=0.0
64      NITMIN(IDY)=0.0
65      DO 3 I=1,24
66      IF (TM(I).GT.92) GO TO 565
67      TEM=(TM(I)-ET)/24.
68      IF (TEM.LT.0.) TEM=0.
69      GO TO 35
70      555 TEMOVR=TM(I)-92.
71      TEM=(37.3-TEMOVR)/24.
72      35 CONTINUE
73      X=TM(I)-T1
74      IF(X)39,39,32
75      32 IF(X-TD)34,34,33
76      33 X=TD-1.423*(X-TD)
77      34 EDCORN(IDY)=EDCORN(IDY)+X/24.
78      39 CONTINUE
79      IF(I.GT.6)GO TO 563
80      NITMIN(IDY-1)=NITMIN(IDY-1)+TM(I)/12.
81      GO TO 561
82      563 IF(I.LT.19)GO TO 561
83      NITMIN(IDY)=NITMIN(IDY)+TM(I)/12.
84      561 ED(IDY)=ED(IDY)+TEM
85      562 TEMAVG(IDY)=TEMAVG(IDY)+TM(I)/24.
86      3 CONTINUE
87      DAYLN=12.14+1.94* $\cos(.01721*(IDY-175))$ 
88      IE $\overline{GG}$ =13.5+DAYLN/2.
89      E $\overline{GLYTM}$ (IDY)=(TM(IE $\overline{GG}$ )+TM(IE $\overline{GG}$ +1)+TM(IE $\overline{GG}$ +2))/3.
90      IF(KK.F0.0) GO TO 304
91      T $\overline{CLOUD}$ (IDY)=(CLOUD(IE $\overline{GG}$ )+CLOUD(IE $\overline{GG}$ +1)+CLOUD(IE $\overline{GG}$ +2))/3.
92      304 CONTINUE
93      202 RETURN
94      END

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1      SUBROUTINE TRKGRM
2      C THIS SUBROUTINE PROVIDES A DYNAMIC POPULATION MODEL
3      C FOR TRICHOGRAMMA.
4      COMMON KODE(20),DUM40(5119),SAREA(370),DUM41(370),ILAST,DUM42(748)
5      A,IGEN(370,7,2),DUM43(2590),TOTAL(370,9,2),POS(370,7,2),PARSIT(370,
6      32),PREDOP(370,2),DUM45(743),I,DUM46(1863),IN,DUM47(410),TP,DEATH(5
7      0,2),STPK(3)
8      DIMENSION FERATE(20)
9      DATA TKSURV/1./
10     DATA FERATE/.5,.8,.87,.95,.95,.95,.93,.9,.82,.74,.68,.6,.55,.5,.45
11     2,.4,.3,.2,.1,0./
12     IF(TP.LT.1)RETURN
13     TOTAL(I,9,IN)=TOTAL(I,9,IN)+TP
14     TS=TP
15     K=I+IGEN(I,1,IN)+IGEN(I,2,IN)-1
16     IF(K.GT.ILAST)RETURN
17     II=I+1
18     DO 100 J=II,K
19     X=PREDOP(J,1)*(1.-POS(J,2,IN))
20     X=(1.-X)*(1.-DEATH(1,IN))*(1.-POS(J,7,IN))
21     TS=TS*X
22     TOTAL(J,9,IN)=TOTAL(J,9,IN)+TS
23     TOTAL(J,1,IN)=TOTAL(J,1,IN)+TS
24     100 CONTINUE
25     IF(KODE(5).NE.4) RETURN
26     C ASSUME EGGS ARE HARD TO FIND AS FUNCTION OF SAREA
27     C ASSUME 2 FEMALES EMERGE FROM EACH EGG.
28     TS=TS*2.*SAREA(II)
29     K=K+1
30     KK=K+10
31     IF(KK.GT.ILAST)KK=ILAST
32     IAGE=1

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33      DO 200 J=K, KK
34      TS=TS*TKSURV
35      PARSIT(J,1)=TS*FERATE(IAGE)+PARSIT(J,1)
36      IAGE=IAGE+1
37      200 CONTINUE
38      RETURN
39      END

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```

1      FUNCTION DISTR(DISTS)
2      C THIS SUBROUTINE CALCULATES THE DEVELOPMENT DISTRIBUTIONS OF COHERTS
3      C OF EGGS, LARVAE, AND PUPA. A NORMAL DISTRIBUTION IS ASSUMED (STINNER
4      C 1974). THE ARRAY GAUS IS AN ACCUMULATION OF THE NORMAL DISTRIBUTION
5      C PROBABILITIES FOR + OR - 4 STANDARD DEVIATIONS FROM THE MEAN.
6      COMMON DUM72(30328),X,DUM73(418),XBAR,XSD,DUM74
7      DIMENSION GAUS1(40),GAUS2(40),GAUS(81)
8      EQUIVALENCE (GAUS1(1),GAUS(2)),(GAUS2(1),GAUS(42))
9      DATA GAUS(1)/.00003/
10     DATA GAUS1/.00005,.00007,.0001,.00015,.00020,.0003,.0005,.0007,.00
11     110,.0013,.0019,.0026,.0035,.0047,.0062,.0082,.0107,.0139,.0179,.02
12     228,.0287,.0359,.0446,.0548,.0668,.0808,.0968,.1151,.1357,.1587,.18
13     341,.2119,.2420,.2743,.3085,.3446,.3821,.4207,.4602,.5000/
14     DATA GAUS2/.5388,.5793,.6179,.6554,.6915,.7257,.7580,.7881,.8159,.
15     28413,.8643,.8849,.9032,.9192,.9332,.9452,.9554,.9641,.9713,.9772,.
16     39821,.9861,.9893,.9918,.9938,.9953,.9965,.9974,.9981,.9987,.9990,.
17     49993,.9995,.9997,.9998,.99985,.9999,.99993,.99995,.99997/
18     Y=(X-XBAR+.5)/XSD
19     IF(Y.GT.-4.)GO TO 1
20     DISTR=0.
21     RETURN
22     1 CONTINUE
23     IF(Y.LT.4.)GO TO 2
24     DISTR=1.-DISTS
25     DISTS=1.
26     RETURN
27     2 CONTINUE
28     INDEX=IFIX((Y+4.1)*10.)
29     Y=GAUS(INDEX)
30     DISTR=Y-DISTS
31     DISTS=Y
32     RETURN
33     END

```

## EXAMPLE INPUT

1	3	1	27	0	1	1	160	1	1	205	1	1	1	1	1	102	1	3
2	45	40	40	30	150	900	300	45	40	40	30	150	900	400				
3	82	146																
4	59	236																
5	56		71				14000			2	18	18	59	1				
6	060		010															
7	150		200															
8	1	1	1															
9				1	1	1												
10																		
11	82		10															
12	83																	
13	84		02															
14	85																	
15	86		08		02													
16	87																	
17	88																	
18	89		02															
19	90		02		04													
20	91		12		02													
21	92		02															
22	93																	
23	94				01													
24	95		02															
25	96		08		06													
26	97		10		07													
27	98		81		37													
28	99		09		10													
29	100		01		04													
30	101				02													
31	102		01															
32	103																	
33																		

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ALL CROPS LT 1975
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34	104	78	24	ALL CROPS LT 1975		
35	105	02	04	ALL CROPS LT 1975		
36	106	11	03	ALL CROPS LT 1975		
37	107		5	CORN LT 1975 ACTU		
38	108			CORN LT 1975 ACTU		
39	109			CORN LT 1975 ACTU		
40	110	10		CORN LT 1975 ACTU		
41	111	25		CORN LT 1975 ACTU		
42	112	15		CORN LT 1975 ACTU		
43	113	10		CORN LT 1975 ACTU		
44	114	05		CORN LT 1975 ACTU		
45	115	20		CORN LT 1975 ACTU		
46	116	20	02	CORN LT 1975 ACTU		
47	117	49	13	CORN LT 1975 ACTU		
48	118	25	00	CORN LT 1975 ACTU		
49	119	23	28	CORN LT 1975 ACTU		
50	120	10	00	CORN LT 1975 ACTU		
51	121	55	50	CORN LT 1975 ACTU		
52	122	105	25	CORN LT 1975 ACTU		
53	123	95	43	CORN LT 1975 ACTU		
54	124	60	18	CORN LT 1975 ACTU		
55	125	108	15	CORN LT 1975 ACTU		
56	126	190	50	CORN LT 1975 ACTU		
57	127	17	07	CORN LT 1975 ACTU		
58	128	03	03	CORN LT 1975 ACTU		
59	129	50	12	CORN LT 1975 ACTU		
60	130	05	28	CORN LT 1975 ACTU		
61	131	20	03	CORN LT 1975 ACTU		
62	132			CORN LT 1975 ACTU		
63	133	03	05	CORN LT 1975 ACTU		
64	134	03		CORN LT 1975 ACTU		
65	135	03	05	CORN LT 1975 ACTU		
66	136	05		CORN LT 1975 ACTU		
67	137	06	03	CORN LT 1975 ACTU		
68	138	23	20	CORN LT 1975 ACTU		
69	139	28	33	CORN LT 1975 ACTU		
70	140	33	10	CORN LT 1975 ACTU		
71	141	30	20	CORN LT 1975 ACTU		
72	142	38	28	CORN LT 1975 ACTU		
73	143	110	78	CORN LT 1975 ACTU		
74	144	65	23	CORN LT 1975 ACTU		
75	145	65	15	CORN LT 1975 ACTU		
76	146	30	35	CORN LT 1975 ACTU		
77						
78						
79	1	59	75	66	64	61
80	1	60	75	55	54	53
81	1	61	75	59	56	54
82	1	62	75	58	57	56
83	1	63	75	40	40	40
84	1	64	75	41	41	40
85	1	65	75	53	54	54
86	1	66	75	69	69	69
87	1	67	75	47	46	43
88	1	68	75	55	53	51
89	1	69	75	64	62	62
90	1	70	75	53	54	55
91	1	71	75	72	72	71
92	1	72	75	42	41	42
93	1	73	75	32	30	29
94	1	74	75	45	47	46
95	1	75	75	60	60	59
96	1	76	75	51	51	51
97	1	77	75	55	55	53
98	1	78	75	47	45	44
99	1	79	75	53	54	54
100	1	80	75	61	63	63
101	1	81	75	59	59	59
102	1	82	75	70	70	71
103	1	83	75	56	54	52
104	1	84	75	51	52	51
105	1	85	75	36	32	33
106	1	86	75	70	70	70
107	1	87	75	71	71	71
108	1	88	75	45	45	44
109	1	89	75	35	35	34
110	1	90	75	43	41	41
111	1	91	75	48	46	46
112	1	92	75	62	62	64
113	1	93	75	41	39	39
114	1	94	75	46	45	44
115	1	95	75	53	52	51
116	1	96	75	60	60	59
117	1	97	75	60	59	58
118	1	98	75	70	65	62
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				113	113	113
				114	114	114
				115	115	115
				116	116	116
				117	117	117
				118	118	118

119	1	99	75	62	62	62	63	62	62	62	65	69	72	76	77	77	79	80	79	77	74	71	70	68
120	1	100	75	66	66	67	63	64	62	62	64	65	72	72	71	73	76	70	77	76	66	63	61	59
121	1	101	75	55	55	54	53	52	51	53	59	61	66	68	69	70	70	71	73	70	67	63	61	59
122	1	102	75	55	54	52	51	49	50	51	54	59	60	63	65	66	68	69	70	67	65	62	61	60
123	1	103	75	57	57	55	55	56	56	55	56	59	61	64	65	62	62	61	62	61	59	56	55	56
124	1	104	75	55	55	54	54	53	53	53	54	55	55	57	59	62	63	66	67	68	65	59	57	56
125	1	105	75	47	47	46	46	46	46	47	51	55	57	58	62	67	69	72	73	73	72	66	62	61
126	1	106	75	54	53	51	51	50	50	52	58	64	60	72	74	76	78	78	77	77	74	70	68	66
127	1	107	75	64	65	66	66	66	67	67	68	70	71	72	72	78	80	80	79	78	76	75	75	74
128	1	108	75	73	73	72	72	72	72	72	74	77	79	80	81	81	83	84	85	80	78	76	75	72
129	1	109	75	61	59	60	60	60	55	55	59	62	64	67	70	73	73	75	75	74	72	67	64	62
130	1	110	75	60	60	59	57	57	56	57	59	62	67	72	74	74	75	76	75	72	70	67	64	63
131	1	111	75	61	60	59	60	60	60	60	60	61	62	63	65	68	69	70	68	66	65	63	63	62
132	1	112	75	61	62	62	62	63	64	64	65	67	68	70	76	79	79	81	81	80	78	75	73	71
133	1	113	75	70	70	69	70	69	69	69	70	73	76	77	78	78	80	81	80	79	77	75	74	73
134	1	114	75	72	72	72	71	70	70	71	72	75	79	82	83	85	85	86	85	82	80	78	75	74
135	1	115	75	72	72	72	71	71	71	72	74	76	79	81	82	83	84	85	85	83	81	79	76	75
136	1	116	75	74	74	74	74	73	73	73	76	77	80	81	81	82	83	85	84	82	79	78	76	76
137	1	117	75	74	73	73	72	71	71	72	74	76	79	81	85	83	84	84	85	82	80	77	76	75
138	1	118	75	73	73	73	73	72	72	72	72	73	76	79	81	85	83	84	84	85	82	80	77	76
139	1	119	75	67	67	67	68	68	67	70	73	75	79	81	82	83	84	84	81	79	76	68	69	69
140	1	120	75	63	63	63	65	66	68	69	70	70	68	65	70	67	73	79	79	80	78	75	71	69
141	1	121	75	67	66	65	64	61	61	64	68	71	73	76	76	79	81	81	79	78	77	74	73	73
142	1	122	75	69	69	68	69	69	68	69	70	72	74	77	79	79	79	80	80	79	78	76	75	75
143	1	123	75	72	72	72	73	73	73	74	75	78	78	79	80	80	78	81	82	80	80	77	74	73
144	1	124	75	73	69	68	67	67	67	68	71	74	75	76	81	81	84	80	84	80	80	69	68	64
145	1	125	75	66	66	64	64	64	65	66	69	72	75	79	81	83	82	84	83	82	81	79	77	77
146	1	126	75	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
147	1	127	75	73	73	73	73	73	74	75	74	77	79	82	84	85	86	88	85	83	72	74	65	65
148	1	128	75	65	65	65	65	65	65	65	66	68	69	71	78	79	83	84	83	82	80	78	77	62
149	1	129	75	66	63	62	62	60	61	65	70	73	74	77	80	81	83	84	84	82	81	78	76	76
150	1	130	75	71	72	69	68	67	67	67	67	67	67	67	71	75	77	79	81	79	81	79	76	73
151	1	131	75	70	70	70	70	69	69	70	71	73	75	79	80	79	68	65	67	67	68	66	64	65
152	1	132	75	64	64	65	64	62	61	64	69	72	76	78	79	81	81	82	82	82	81	77	74	73
153	1	133	75	68	69	67	66	65	66	67	70	73	75	77	80	80	80	81	83	82	79	75	75	73
154	1	134	75	62	62	62	61	60	61	62	66	69	71	73	75	76	78	75	75	74	74	69	66	64
155	1	135	75	62	62	61	61	61	62	63	66	69	68	69	69	74	73	72	73	75	72	70	67	65
156	1	136	75	64	64	63	63	63	63	64	69	72	75	77	79	80	82	80	81	81	79	71	69	68
157	1	137	75	60	60	61	61	59	58	64	70	74	77	79	80	77	81	82	82	81	80	76	73	68
158	1	138	75	65	64	64	64	64	64	67	72	76	79	82	83	85	83	85	85	82	82	79	77	75
159	1	139	75	67	66	66	65	65	65	68	73	76	79	82	82	83	85	85	84	82	80	79	78	77
160	1	140	75	74	74	74	74	74	74	73	75	76	79	84	85	85	85	87	83	84	83	80	80	78
161	1	141	75	75	75	75	75	75	76	76	78	80	81	84	87	86	86	86	85	84	83	81	79	77
162	1	142	75	74	74	74	73	73	73	74	77	80	81	85	86	87	87	88	87	85	83	80	78	75
163	1	143	75	70	70	70	70	70	70	73	75	77	80	80	79	72	75	76	76	76	74	74	74	73
164	1	144	75	70	69	68	69	68	72	70	70	73	76	78	81	79	65	64	64	64	64	64	64	64
165	1	145	75	61	61	61	61	62	62	65	69	75	76	78	79	82	82	85	84	83	84	81	78	75
166	1	146	75	69	70	71	72	72	72	73	75	79	83	83	86	86	87	88	89	88	83	77	74	73
167	1	147	75	71	72	70	70	70	70	71	73	76	80	81	83	84	87	86	87	86	82	78	75	73
168	1	148	75	70	69	68	68	67	67	70	73	75	79	79	78	69	73	74	74	75	73	72	72	70
169	1	149	75	68	69	70	70	70	71	73	77	77	65	64	71	75	75	80	76	74	76	75	72	72
170	1	150	75	70	67	67	65	65	68	69	70	75	77	75	71	68	67	68	69	68	67	67	66	66
171	1	151	75	60	60	60	59	59	59	63	67	70	73	74	76	77	78	79	79	78	74	69	66	66
172	1	152	75	59	59	59	58	58	60	64	70	74	76	78	80	80	80	82	82	81	80	77	72	70
173	1	153	75	65	64	65	62	61	62	69	73	77	79	82	83	82	85	85	85	84	85	79	75	73
174	1	154	75	68	67	65	65	65	63	69	72	76	79	81	82	85	86	87	86	85	84	80	75	74
175	1	155	75	71	71	72	73	73	74	75	78	82	84	87	89	82	88	89	89	87	85	82	79	77
176	1	156	75	74	75	75	74	75	76	77	79	83	85	86	89	88	87	90	88	88	86	83	80	80
177	1	157	75	75	74	74	75	75	75	76	79	83	85	86	88	88	90	89	90	91	88	83	81	80
178	1	158	75	74	73	73	74	75	75	77	78	81	83	85	87	88	88	90	90	88	88	85	82	81
179	1	159	75	76	75	75	75	74	74	77	78	80	84	85	87	88	88	86	83	82	80	79	78	77
180	1	160	75	77	76	76	76	76	77	77	76	81	82	81	81	85	85	85	86	85	82	71	73	71
181	1	161	75	69	69	68	68	68	68	70	72	75	75	76	76	75	77	80	80	80	79	79	74	73
182	1	162	75	70	70	70	68	69	71	73	75	77	81	81	81	83	84	84	83	82	80	77	75	72
183	1	163	75	68	67	67	67	66	68	71	74	77	79	82	83	84	86	86	86	86	85	83	79	76
184	1	164	75	71	72	71	71	70	71	75	79	82	85	86	88	89	89	91	90	89	87	83	79	78
185	1	165	75	75	75	74	74	75	74	76	80	82	84	87	88	89	90	90	91	90	87	84	82	81
186	1	166	75	77	77	77	77	76	75	77	77	77	80	84	85	86	87	88	89	86	85	83	82	81
187	1	167	75	77	77</																			

204	1	184	75	73	72	73	72	72	71	75	79	81	84	85	87	88	89	90	89	89	87	81	79	76
205	1	185	75	74	74	72	73	72	72	76	80	83	85	88	87	88	89	90	89	89	88	80	73	77
206	1	186	75	73	74	73	72	72	73	76	79	82	85	87	87	88	88	90	89	88	88	86	83	79
207	1	187	75	74	74	73	72	72	71	74	78	83	85	87	89	90	91	91	92	89	87	85	80	78
208	1	188	75	75	75	74	73	74	74	76	79	82	84	87	88	90	90	91	91	89	88	86	82	80
209	1	189	75	75	75	75	74	74	74	75	78	81	85	86	89	90	91	91	92	91	90	86	82	80
210	1	190	75	78	77	76	75	75	75	77	80	83	85	87	90	92	93	93	92	92	90	86	82	81
211	1	191	75	78	77	76	75	74	76	77	77	82	83	83	83	86	86	88	88	88	87	84	80	79
212	1	192	75	74	74	74	74	74	73	73	73	74	78	81	85	86	86	88	88	88	87	84	80	79
213	1	193	75	74	72	73	73	73	73	75	79	83	85	85	85	84	80	82	76	78	77	76	74	71
214	1	194	75	70	70	69	69	69	69	70	75	80	82	85	87	86	86	88	88	88	87	84	80	79
215	1	195	75	69	69	69	69	69	68	72	76	80	80	82	84	86	86	88	88	80	74	74	73	72
216	1	196	75	70	69	69	69	70	70	71	74	77	80	83	84	86	87	83	79	80	80	78	76	75
217	1	197	75	72	71	70	71	70	70	71	75	77	80	83	85	85	83	85	85	84	83	82	79	77
218	1	198	75	74	73	72	71	70	71	74	78	82	85	86	87	88	88	89	88	77	75	76	76	76
219	1	199	75	75	74	73	72	72	72	75	79	81	81	85	87	88	88	88	86	85	84	84	81	80
220	1	200	75	75	75	75	74	74	74	76	80	81	84	85	88	89	88	89	80	86	87	82	82	80
221	1	201	75	75	76	73	72	72	75	78	82	82	85	86	86	90	91	91	89	87	85	85	82	81
222		59	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

## EXAMPLE OUTPUT

HOURLY TEMPERATURE INPUT FROM DAYS 59 TO 201  
MAX/MIN TEMPERATURE INPUT FROM DAYS 202 TO 236

INPUT FOR THE MODEL HAS BEEN HELIOTHS ZFA ONLY  
INPUT READ FROM 82 TO 146

FACTD= 0.585 RUN NO.= 0 ZFA EGGRT= 0.900 VIRS EGGRT= 0.900  
ZFA EGGS/MOTH = 300. VIRS EGGS/MOTH=\*\*\*\*\*PLANTS/ACRE=14000.

CROP PHENOLOGY: IE= 71,IA= 80,IF=140,IM=155

DAY	NJ	EGGPAR	1-3PAR	EGGPRD	1-3PRD	TCLDUD	NITIN	TEHVG	ADMOON	EGLYTH	SQUARES	BOLLS	EARS	HEADS	SAREA
82	0.003	0.000	0.007	0.010	0.0	58.8	70.5	0.730	68.0	0.	0.	0.	0.	0.	1.2
83	0.004	0.001	0.011	0.015	0.0	51.7	59.5	0.610	58.7	0.	0.	0.	0.	0.	1.2
84	0.006	0.001	0.015	0.020	0.0	57.0	63.1	0.450	65.7	0.	0.	0.	0.	0.	1.3
85	0.007	0.001	0.019	0.025	0.0	70.1	63.2	0.240	69.3	0.	0.	0.	0.	0.	1.3
86	0.009	0.001	0.022	0.030	0.0	71.8	74.2	0.240	73.7	0.	0.	0.	0.	0.	1.4
87	0.010	0.002	0.026	0.035	0.0	44.2	58.7	0.530	44.7	0.	0.	0.	0.	0.	1.5
88	0.012	0.002	0.030	0.040	0.0	35.7	40.3	0.750	38.0	0.	0.	0.	0.	0.	1.5
89	0.013	0.002	0.034	0.045	0.0	43.8	44.8	0.890	46.7	0.	0.	0.	0.	0.	1.5
90	0.015	0.002	0.037	0.050	0.0	48.3	50.2	0.960	50.7	0.	0.	0.	0.	0.	1.5
91	0.016	0.003	0.041	0.055	0.0	62.2	59.1	1.000	62.7	0.	0.	0.	0.	0.	1.5
92	0.018	0.003	0.045	0.060	0.0	42.7	58.6	1.000	50.3	0.	0.	0.	0.	0.	1.6
93	0.019	0.003	0.049	0.065	0.0	45.7	58.9	1.000	57.3	0.	0.	0.	0.	0.	1.6
94	0.021	0.003	0.052	0.070	0.0	53.5	54.1	1.000	52.0	0.	0.	0.	0.	0.	1.6
95	0.022	0.004	0.056	0.075	0.0	60.4	59.8	1.000	61.0	0.	0.	0.	0.	0.	1.6
96	0.024	0.004	0.060	0.080	0.0	61.2	65.9	1.000	66.7	0.	0.	0.	0.	0.	1.6
97	0.025	0.004	0.064	0.085	0.0	65.3	64.6	1.000	66.3	0.	0.	0.	0.	0.	1.8
98	0.027	0.004	0.067	0.090	0.0	62.4	63.3	1.000	63.3	0.	0.	0.	0.	0.	1.8
99	0.028	0.005	0.071	0.095	0.0	66.0	69.3	1.000	69.7	0.	0.	0.	0.	0.	1.9
100	0.030	0.005	0.075	0.100	0.0	57.2	65.7	1.000	63.3	0.	0.	0.	0.	0.	2.0
101	0.031	0.005	0.077	0.103	0.0	55.2	61.2	1.000	61.0	0.	0.	0.	0.	0.	2.0
102	0.032	0.005	0.079	0.106	0.0	57.4	59.2	1.000	61.0	0.	0.	0.	0.	0.	2.0
103	0.033	0.005	0.081	0.109	0.0	54.7	58.1	1.000	55.7	0.	0.	0.	0.	0.	2.1
104	0.033	0.006	0.084	0.114	0.0	50.2	57.2	0.990	57.3	0.	0.	0.	0.	0.	2.1
105	0.034	0.006	0.086	0.117	0.0	56.0	58.2	0.990	63.0	0.	0.	0.	0.	0.	2.1
106	0.035	0.006	0.088	0.120	0.0	65.9	64.4	0.980	68.0	0.	0.	0.	0.	0.	2.2
107	0.036	0.006	0.090	0.123	0.0	73.1	72.0	0.970	74.7	0.	0.	0.	0.	0.	2.2
108	0.037	0.006	0.092	0.126	0.0	65.0	75.5	0.940	74.3	0.	0.	0.	0.	0.	2.2
109	0.038	0.006	0.094	0.129	0.0	60.7	64.7	0.910	64.3	0.	0.	0.	0.	0.	2.4
110	0.039	0.006	0.096	0.132	0.0	61.7	65.1	0.860	64.7	0.	0.	0.	0.	0.	2.5
111	0.039	0.007	0.099	0.135	0.0	62.1	62.8	0.820	62.0	0.	0.	0.	0.	0.	2.5
112	0.040	0.007	0.101	0.138	0.0	70.7	70.5	0.730	71.7	0.	0.	0.	0.	0.	2.6
113	0.041	0.007	0.103	0.141	0.0	71.9	73.8	0.610	73.0	0.	0.	0.	0.	0.	2.7
114	0.042	0.007	0.105	0.144	0.0	72.9	76.6	0.450	74.0	0.	0.	0.	0.	0.	2.7
115	0.043	0.007	0.107	0.147	0.0	74.5	76.9	0.240	75.0	0.	0.	0.	0.	0.	3.0
116	0.044	0.007	0.109	0.149	0.0	74.2	77.5	0.240	76.0	0.	0.	0.	0.	0.	3.1
117	0.045	0.007	0.111	0.151	0.0	73.9	77.1	0.530	75.3	0.	0.	0.	0.	0.	3.2
118	0.046	0.008	0.114	0.154	0.0	67.4	68.5	0.750	68.3	0.	0.	0.	0.	0.	3.3
119	0.046	0.008	0.116	0.157	0.0	65.5	72.9	0.890	67.3	0.	0.	0.	0.	0.	3.3
120	0.047	0.008	0.118	0.160	0.0	66.9	69.8	0.960	69.3	0.	0.	0.	0.	0.	3.4
121	0.048	0.008	0.120	0.163	0.0	70.8	71.9	1.000	73.3	0.	0.	0.	0.	0.	3.5
122	0.049	0.008	0.122	0.166	0.0	73.3	73.9	1.000	74.7	0.	0.	0.	0.	0.	3.6
123	0.050	0.008	0.124	0.169	0.0	70.8	75.8	1.000	72.7	0.	0.	0.	0.	0.	3.7
124	0.051	0.008	0.126	0.172	0.0	65.1	72.5	1.000	65.0	0.	0.	0.	0.	0.	3.8
125	0.051	0.009	0.129	0.175	0.0	72.9	72.2	1.000	73.3	0.	0.	0.	0.	0.	3.9
126	0.052	0.009	0.131	0.178	0.0	74.8	77.2	1.000	76.7	0.	0.	0.	0.	0.	4.0
127	0.053	0.009	0.133	0.181	0.0	65.7	75.3	1.000	65.0	0.	0.	0.	0.	0.	4.1
128	0.054	0.009	0.135	0.184	0.0	64.7	71.4	1.000	64.0	0.	0.	0.	0.	0.	4.2
129	0.055	0.009	0.137	0.187	0.0	71.8	73.2	1.000	75.0	0.	0.	0.	0.	0.	4.3
130	0.056	0.009	0.139	0.190	0.0	71.4	72.7	1.000	73.3	0.	0.	0.	0.	0.	4.4
131	0.057	0.009	0.141	0.193	0.0	69.9	69.5	1.000	64.3	0.	0.	0.	0.	0.	4.5
132	0.057	0.010	0.144	0.196	0.0	69.5	72.5	1.000	72.7	0.	0.	0.	0.	0.	4.5
133	0.058	0.010	0.146	0.199	0.0	66.4	73.2	0.990	73.3	0.	0.	0.	0.	0.	4.6
134	0.059	0.010	0.148	0.202	0.0	62.7	67.5	0.990	64.0	0.	0.	0.	0.	0.	4.7
135	0.060	0.010	0.150	0.205	0.0	64.1	66.7	0.980	65.0	0.	0.	0.	0.	0.	4.8
136	0.060	0.010	0.150	0.208	0.0	63.2	70.8	0.970	67.3	0.	0.	0.	0.	0.	4.9
137	0.060	0.010	0.150	0.211	0.0	67.0	71.0	0.940	70.0	0.	0.	0.	0.	0.	5.0
138	0.060	0.010	0.150	0.214	0.0	69.8	74.6	0.910	75.0	0.	0.	0.	0.	0.	5.1
139	0.060	0.010	0.150	0.217	0.0	75.0	75.4	0.860	77.0	0.	0.	0.	0.	0.	5.1
140	0.060	0.010	0.150	0.220	0.0	76.2	78.8	0.820	78.0	0.	0.	0.	0.	0.	5.3
141	0.060	0.010	0.150	0.223	0.0	75.2	79.5	0.730	77.3	0.	0.	0.	0.	0.	5.4
142	0.060	0.010	0.150	0.226	0.0	72.6	78.8	0.610	75.3	0.	0.	0.	0.	0.	5.5
143	0.060	0.010	0.150	0.229	0.0	71.1	73.7	0.450	73.0	0.	0.				

148	0.060	0.010	0.150	0.200	0.0	69.7	71.7	0.890	70.3	0.	0.	896.7	0.	6.0
149	0.060	0.010	0.150	0.200	0.0	69.6	72.2	0.960	72.3	0.	0.	1044.9	0.	6.0
150	0.060	0.010	0.150	0.200	0.0	62.2	68.1	1.000	65.7	0.	0.	1148.9	0.	6.0
151	0.060	0.010	0.150	0.200	0.0	62.5	68.6	1.000	66.3	0.	0.	1235.0	0.	6.0
152	0.060	0.010	0.150	0.200	0.0	66.5	70.8	1.000	70.3	0.	0.	1305.1	0.	6.0
153	0.060	0.010	0.150	0.200	0.0	69.1	74.3	1.000	72.7	0.	0.	1356.6	0.	6.0
154	0.060	0.010	0.150	0.200	0.0	73.2	75.4	1.000	73.7	0.	0.	1385.9	0.	6.0
155	0.060	0.010	0.150	0.200	0.0	76.1	79.7	1.000	77.3	0.	0.	1400.5	0.	6.0
156	0.058	0.010	0.144	0.192	0.0	76.9	81.2	1.000	79.7	0.	0.	1400.5	0.	6.0
157	0.055	0.009	0.138	0.184	0.0	76.4	81.2	1.000	79.7	0.	0.	1400.5	0.	6.0
158	0.053	0.009	0.132	0.176	0.0	77.6	81.2	1.000	80.7	0.	0.	1400.5	0.	6.0
159	0.050	0.008	0.126	0.168	0.0	76.8	79.6	1.000	77.3	0.	0.	1400.5	0.	6.0
160	0.048	0.008	0.120	0.160	0.0	77.5	79.5	1.000	77.3	0.	0.	1400.5	0.	6.0
161	0.046	0.008	0.114	0.152	0.0	71.5	73.5	1.000	73.0	0.	0.	1400.5	0.	6.0
162	0.043	0.007	0.108	0.144	0.0	70.0	75.8	1.000	73.0	0.	0.	1400.5	0.	6.0
163	0.041	0.007	0.102	0.136	0.0	74.1	76.9	0.990	77.3	0.	0.	1400.5	0.	6.0
164	0.038	0.006	0.096	0.128	0.0	76.6	80.3	0.990	78.7	0.	0.	1400.5	0.	6.0
165	0.036	0.006	0.090	0.120	0.0	78.6	81.9	0.980	81.0	0.	0.	1400.5	0.	6.0
166	0.034	0.006	0.084	0.112	0.0	78.4	81.0	0.970	81.0	0.	0.	1400.5	0.	6.0
167	0.031	0.005	0.078	0.104	0.0	78.2	82.2	0.940	79.7	0.	0.	1400.5	0.	6.0
168	0.029	0.005	0.072	0.096	0.0	79.7	83.0	0.910	80.3	0.	0.	1400.5	0.	6.0
169	0.026	0.004	0.066	0.088	0.0	79.6	83.7	0.860	81.0	0.	0.	1400.5	0.	6.0
170	0.024	0.004	0.060	0.080	0.0	78.4	83.4	0.820	81.0	0.	0.	1400.5	0.	6.0
171	0.022	0.004	0.054	0.072	0.0	78.2	82.0	0.730	80.3	0.	0.	1400.5	0.	6.0
172	0.019	0.003	0.048	0.064	0.0	75.4	80.9	0.610	78.0	0.	0.	1400.5	0.	6.0
173	0.017	0.003	0.042	0.056	0.0	76.7	81.6	0.450	80.3	0.	0.	1400.5	0.	6.0
174	0.014	0.002	0.036	0.048	0.0	75.9	81.1	0.240	80.7	0.	0.	1400.5	0.	6.0
175	0.012	0.002	0.030	0.040	0.0	74.9	78.6	0.240	75.0	0.	0.	1400.5	0.	6.0
176	0.010	0.002	0.024	0.032	0.0	73.3	75.0	0.530	73.0	0.	0.	1400.5	0.	6.0
177	0.007	0.001	0.018	0.024	0.0	71.9	75.2	0.750	71.0	0.	0.	1400.5	0.	6.0
178	0.005	0.001	0.012	0.016	0.0	69.2	71.9	0.890	70.0	0.	0.	1400.5	0.	6.0
179	0.002	0.000	0.006	0.008	0.0	71.5	76.6	0.560	73.0	0.	0.	1400.5	0.	6.0
180	0.0	0.0	0.0	0.0	0.0	74.5	79.2	1.000	76.7	0.	0.	1400.5	0.	6.0
181	0.0	0.0	0.0	0.0	0.0	72.2	78.3	1.000	74.3	0.	0.	1400.5	0.	6.0
182	0.0	0.0	0.0	0.0	0.0	71.6	73.9	1.000	71.7	0.	0.	1400.5	0.	6.0
183	0.0	0.0	0.0	0.0	0.0	74.4	76.8	1.000	77.3	0.	0.	1400.5	0.	6.0
184	0.0	0.0	0.0	0.0	0.0	74.6	79.7	1.000	76.3	0.	0.	1400.5	0.	6.0
185	0.0	0.0	0.0	0.0	0.0	76.7	79.7	1.000	76.3	0.	0.	1400.5	0.	6.0
186	0.0	0.0	0.0	0.0	0.0	76.3	81.1	1.000	80.3	0.	0.	1400.5	0.	6.0
187	0.0	0.0	0.0	0.0	0.0	76.6	81.1	1.000	80.3	0.	0.	1400.5	0.	6.0
188	0.0	0.0	0.0	0.0	0.0	77.3	81.7	1.000	80.3	0.	0.	1400.5	0.	6.0
189	0.0	0.0	0.0	0.0	0.0	78.5	82.0	1.000	80.0	0.	0.	1400.5	0.	6.0
190	0.0	0.0	0.0	0.0	0.0	78.7	83.3	1.000	81.0	0.	0.	1400.5	0.	6.0
191	0.0	0.0	0.0	0.0	0.0	73.9	78.5	1.000	74.0	0.	0.	1400.5	0.	6.0
192	0.0	0.0	0.0	0.0	0.0	73.7	79.2	0.990	78.7	0.	0.	1400.5	0.	6.0
193	0.0	0.0	0.0	0.0	0.0	70.7	76.6	0.990	72.0	0.	0.	1400.5	0.	6.0
194	0.0	0.0	0.0	0.0	0.0	72.2	75.1	0.970	71.0	0.	0.	1400.5	0.	6.0
195	0.0	0.0	0.0	0.0	0.0	72.2	75.1	0.970	71.0	0.	0.	1400.5	0.	6.0
196	0.0	0.0	0.0	0.0	0.0	72.7	76.2	0.940	75.0	0.	0.	1400.5	0.	6.0
197	0.0	0.0	0.0	0.0	0.0	74.5	77.6	0.910	77.3	0.	0.	1400.5	0.	6.0
198	0.0	0.0	0.0	0.0	0.0	74.2	78.4	0.860	75.7	0.	0.	1400.5	0.	6.0
199	0.0	0.0	0.0	0.0	0.0	76.9	79.7	0.820	79.7	0.	0.	1400.5	0.	6.0
200	0.0	0.0	0.0	0.0	0.0	76.4	80.7	0.730	80.3	0.	0.	1400.5	0.	6.0
201	0.0	0.0	0.0	0.0	0.0	77.6	81.2	0.610	80.7	0.	0.	1400.5	0.	6.0
202	0.0	0.0	0.0	0.0	0.0	77.5	84.0	0.450	81.0	0.	0.	1400.5	0.	6.0
203	0.0	0.0	0.0	0.0	0.0	77.5	84.0	0.240	81.0	0.	0.	1400.5	0.	6.0
204	0.0	0.0	0.0	0.0	0.0	77.6	84.0	0.240	81.0	0.	0.	1400.5	0.	6.0
205	0.0	0.0	0.0	0.0	0.0	76.9	84.3	0.530	81.0	0.	0.	1400.5	0.	6.0

EGGS 1-3 LARVAE 4-5 NATURAL MORTALITY  
0.045 0.040 0.040 PUPAE ADULTS  
0.030 0.150

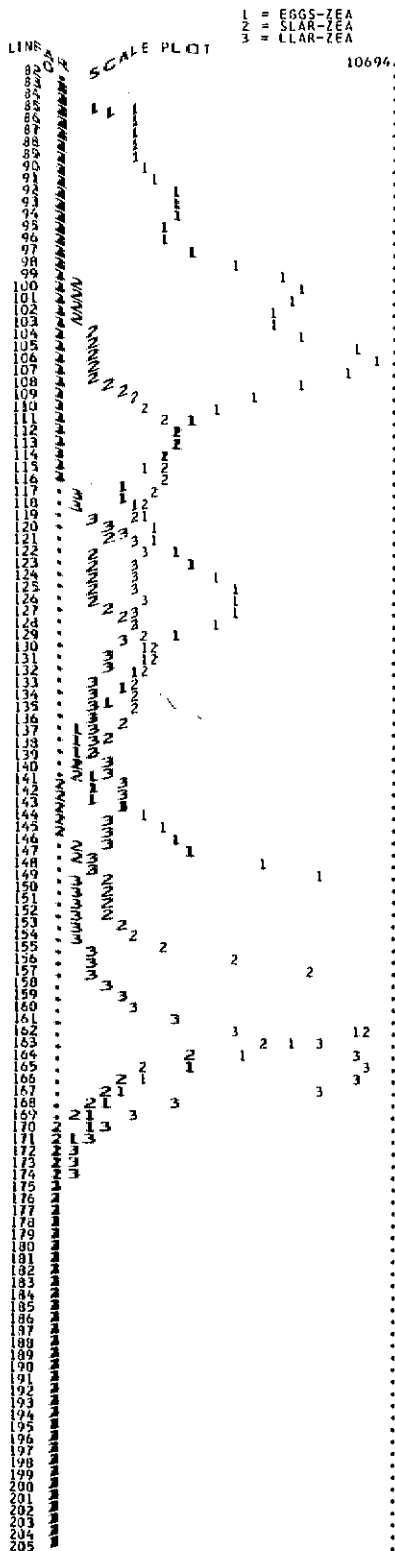
DAYNO.	POSPAR	POSPRD	POS1-3	POS4-5	POSPUP	POSAUT	PCSEGG	EGG 1-3	4-5	PUP	ADP	ADD	E-E	EGLYPR	FGLYCR	PRMGRT	SFXPTD
82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	21	27	34	2	11	94	0.370	0.500	0.0
83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13	23	27	33	3	13	100	0.132	0.510	0.0
84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13	23	27	33	3	13	99	0.325	0.524	0.0
85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12	22	27	33	3	13	95	0.433	0.516	0.0
86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12	22	27	33	3	13	95	0.554	0.556	0.0
87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13	22	27	32	3	14	97	0.011	0.584	0.0
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13	22	26	32	6	18	99	0.011	0.564	0.0
89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12	21	25	31	5	17	94	0.011	0.595	0.0
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11	20	24	30	4	16	89	0.011	0.567	0.0
91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	19	24	29	3	14	85	0.267	0.573	0.0
92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	19	23	28	3	14	83	0.011	0.580	0.0
93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9	18	22	27	3	16	81	0.011	0.582	0.0
94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9	17	21	26	3	16	77	0.115	0.586	0.0
95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8	17	20	25	3	15	73	0.225	0.592	0.0
96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9	16	20	25	3	12	73	0.403	0.600	0.0
97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	16	19	24	3	12	73	0.398	0.608	0.0
98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	16	19	24	3	13	72	0.307	0.614	0.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9	15	18	24	3	11	68	0.514	0.622	0.0
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9	15	18	24	3	12	69	0.314	0.629	0.0
101	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8	14	17	23	3	13	65	0.240	0.633	0.0
102	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8	13	16	22	3	14	63	0.241	0.636	0.0
103	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7	12	15	21	3	14	56	0.067	0.638	0.0
104	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6	11	14	20	3	14	56	0.122	0.643	0.0
105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6	11	14	19	3	12	53	0.478	0.646	0.0
106	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6	10	13	19	3	10	50	0.649	0.651	0.0
107	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6	10	13	19	3	10	50	0.654	0.656	0.0
108	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6	10	13	19	3	12	51	0.362	0.658	0.0
109	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5	9	12	18	3	13	49	0.375	0.659	0.0
110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5	9	12	18	3	13	48	0.285	0.661	0.0
111	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4	9	12	17	3	11	44	0.613	0.682	0.0
112	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4	9	12	17	3	10	44	0.661	0.683	0.0

[illegible]

118	135	45475.	0.019	0.006
118	137	45475.	0.019	0.002
119	138	46767.	0.014	0.002
120	139	47084.	0.011	0.001
121	140	49121.	0.009	0.001
122	142	50465.	0.007	0.002
124	140	53157.	0.005	0.003
125	142	54453.	0.005	0.003
126	144	55989.	0.005	0.005
128	144	58614.	0.006	0.006
129	144	59922.	0.007	0.001
130	145	61206.	0.006	0.007
131	146	62304.	0.007	0.006
132	146	63574.	0.008	0.007
133	147	64804.	0.009	0.007
134	148	65870.	0.010	0.005
134	150	65870.	0.010	0.004
135	152	66813.	0.009	0.002
135	146	66813.	0.0	0.001
137	154	69174.	0.006	0.001
141	152	360.	0.074	0.094
142	153	866.	0.043	0.022
143	154	1560.	0.027	0.020
144	155	2297.	0.017	0.012
146	156	5376.	0.010	0.0
147	154	7367.	0.0	0.007
148	157	8968.	0.004	0.028
149	156	10450.	0.006	0.035
150	159	11490.	0.009	0.040
151	160	12391.	0.012	0.053
151	161	13052.	0.017	0.018
153	162	13567.	0.014	0.027
154	163	13860.	0.014	0.065
155	164	13905.	0.024	0.082
156	165	13648.	0.039	0.107
157	166	13141.	0.065	0.208
158	164	12448.	0.0	0.292
160	167	10461.	0.247	0.565
161	168	8632.	0.373	0.469
162	168	6640.	0.257	0.419
163	170	5840.	0.284	0.339
164	170	3557.	0.286	0.292
165	171	2518.	0.306	0.252
166	172	1657.	0.310	0.258
167	173	555.	0.427	0.391
167	175	955.	0.476	0.204
168	176	441.	0.461	0.281
169	177	148.	0.464	0.422
170	178	1.	0.458	0.678
171	179	1.	0.344	0.0
172	180	1.	0.220	0.571
173	179	1.	0.0	0.674
174	182	1.	0.007	0.952
175	183	1.	0.0	0.913
176	182	1.	0.0	0.905
177	183	1.	0.0	0.887
178	183	1.	0.0	0.0
179	185	1.	0.0	0.808
180	186	1.	0.0	0.779
182	137	1.	0.0	0.0
183	188	1.	0.0	0.0
184	190	1.	0.0	0.0
185	191	1.	0.0	0.0
186	191	1.	0.0	0.0
187	193	1.	0.0	0.0
188	194	1.	0.0	0.0
189	195	1.	0.0	0.0
190	196	1.	0.0	0.0
191	196	1.	0.0	0.0
192	196	1.	0.0	0.0
193	196	1.	0.0	0.0
195	196	1.	0.0	0.0
196	196	1.	0.0	0.0
197	196	1.	0.0	0.0
198	196	1.	0.0	0.0
199	196	1.	0.0	0.0
200	196	1.	0.0	0.0
201	196	1.	0.0	0.0
202	196	1.	0.0	0.0

PRINTOUT OF TOTAL POPULATION OF VARIOUS LIFE STAGES ON ANY DAY												
DAY NO.	EGGS	1ST-3RD	4TH-5TH	PUPAE	P	ADULT	ADULT	INPUT	FEELAC	MIGRATS	IN EGGS	PAR FGG
82	0.	0.	0.	0.	0.	0.	0.	11.	0.	0.	0.	0.
83	760.	0.	0.	0.	0.	0.	0.	8.	0.	0.	76.	0.
84	1318.	0.	0.	0.	0.	0.	0.	6.	0.	0.	131.	1.
85	1696.	0.	0.	0.	0.	0.	0.	2.	0.	0.	167.	1.
86	1756.	0.	0.	0.	0.	0.	0.	2.	0.	0.	172.	2.
87	1758.	0.	0.	0.	0.	0.	0.	1.	0.	0.	171.	3.
88	1733.	0.	0.	0.	0.	0.	0.	3.	0.	0.	166.	4.
89	1822.	0.	0.	0.	0.	0.	0.	6.	0.	0.	173.	5.
90	2131.	0.	0.	0.	0.	0.	0.	8.	0.	0.	202.	5.
91	2583.	0.	0.	0.	0.	0.	0.	9.	0.	0.	244.	6.
92	3037.	0.	0.	0.	0.	0.	0.	6.	0.	0.	286.	6.
93	3246.	0.	0.	0.	0.	0.	0.	3.	0.	0.	303.	7.
94	3155.	7.	0.	0.	0.	0.	0.	3.	0.	0.	294.	8.
95	2909.	54.	0.	0.	0.	0.	0.	4.	0.	0.	275.	10.
96	2769.	171.	0.	0.	0.	0.	0.	14.	0.	0.	259.	12.
97	3407.	365.	0.	0.	0.	0.	0.	22.	0.	0.	319.	11.
98	4736.	420.	0.	0.	0.	0.	0.	29.	0.	0.	435.	10.
99	6454.	449.	0.	0.	0.	0.	0.	20.	0.	0.	600.	9.
100	7134.	524.	0.	0.	0.	0.	0.	11.	0.	0.	663.	10.
101	6759.	662.	0.	0.	0.	0.	0.	12.	0.	0.	635.	12.
102	6104.	794.	0.	0.	0.	0.	0.	12.	0.	0.	535.	15.
103	6268.	852.	0.	0.	0.	0.	0.	23.	0.	0.	537.	15.
104	7299.	844.	0.	0.	0.	0.	0.	34.	0.	0.	631.	14.
105	9197.	840.	0.	0.	0.	0.	0.	25.	0.	0.	805.	13.
106	9768.	840.	0.	0.	0.	0.	0.	14.	0.	0.	869.	14.
107	8780.	1023.	0.	0.	0.	0.	0.	2.	0.	0.	816.	17.
108	7135.	1671.	0.	0.	0.	0.	0.	2.	0.	0.	622.	21.
109	5636.	2019.	1.	0.	0.	0.	0.	4.	0.	0.	476.	26.
110	4241.	2334.	5.	0.	0.	0.	0.	8.	0.	0.	372.	34.
111	3428.	2841.	26.	0.	0.	0.	0.	10.	0.	0.	294.	39.
112	3215.	3220.	71.	0.	0.	0.	0.	7.	0.	0.	251.	39.
113	3255.	3282.	145.	0.	0.	0.	0.	4.	0.	0.	219.	36.

114	2776.	2988.	241.	0.	0.	0.	2.	0.	0.	190.	39.	0.	0.
115	2057.	2832.	331.	0.	0.	0.	3.	0.	0.	150.	48.	0.	0.
116	1617.	2875.	471.	0.	0.	0.	3.	0.	0.	114.	53.	0.	0.
117	1639.	2875.	571.	0.	0.	0.	3.	0.	0.	102.	53.	0.	0.
118	1835.	2137.	996.	0.	0.	0.	8.	0.	0.	120.	40.	0.	0.
119	2062.	1687.	1231.	0.	0.	0.	8.	0.	0.	150.	34.	0.	0.
120	2417.	1244.	1527.	0.	0.	0.	9.	0.	0.	175.	27.	0.	0.
121	2610.	851.	1866.	0.	0.	0.	13.	0.	0.	214.	25.	0.	0.
122	3659.	859.	2044.	2.	0.	0.	18.	0.	0.	257.	22.	0.	0.
123	3643.	878.	2167.	1.	0.	0.	21.	0.	0.	326.	18.	0.	0.
124	4121.	772.	1967.	38.	0.	0.	21.	0.	0.	326.	18.	0.	0.
125	4734.	959.	2020.	95.	0.	0.	22.	0.	0.	442.	17.	0.	0.
126	5007.	1162.	2023.	149.	0.	0.	19.	0.	0.	472.	17.	0.	0.
127	4835.	1444.	1918.	206.	0.	0.	13.	0.	0.	453.	20.	0.	0.
128	4204.	1765.	1726.	265.	0.	0.	8.	0.	0.	392.	24.	0.	0.
129	3240.	2110.	1514.	419.	0.	0.	5.	0.	0.	296.	31.	0.	0.
130	2249.	2310.	1570.	378.	0.	0.	4.	0.	0.	209.	40.	0.	0.
131	2229.	2248.	1043.	499.	0.	0.	5.	0.	0.	139.	38.	0.	0.
132	1784.	2129.	824.	953.	0.	0.	2.	0.	0.	129.	38.	0.	0.
133	1424.	1992.	701.	1168.	0.	0.	2.	0.	0.	93.	47.	0.	0.
134	1102.	1767.	770.	1310.	0.	0.	1.	0.	0.	65.	52.	0.	0.
135	855.	1697.	909.	1324.	0.	0.	1.	0.	0.	46.	56.	0.	0.
136	666.	1410.	834.	1292.	0.	0.	2.	0.	0.	35.	60.	0.	0.
137	673.	1173.	983.	1303.	0.	0.	2.	0.	0.	30.	56.	0.	0.
138	620.	869.	957.	1363.	0.	0.	4.	0.	0.	44.	47.	0.	0.
139	714.	574.	1129.	1420.	0.	0.	4.	0.	0.	33.	30.	0.	0.
140	786.	408.	1209.	1401.	0.	0.	4.	0.	0.	54.	30.	0.	0.
141	851.	270.	1371.	1368.	5.	0.	9.	0.	0.	64.	26.	0.	0.
142	851.	224.	1413.	1326.	18.	0.	4.	0.	0.	84.	25.	0.	0.
143	1468.	310.	1370.	1280.	39.	0.	12.	0.	0.	122.	17.	0.	0.
144	2239.	235.	1280.	1255.	69.	0.	12.	0.	0.	207.	14.	0.	0.
145	2679.	273.	1180.	1255.	77.	0.	19.	0.	0.	77.	6.	0.	0.
146	3230.	354.	1047.	1199.	87.	0.	19.	0.	0.	305.	15.	0.	0.
147	3669.	550.	880.	1157.	132.	0.	23.	0.	0.	341.	15.	0.	0.
148	5873.	754.	719.	1121.	193.	0.	23.	0.	0.	552.	15.	0.	0.
149	8004.	1059.	550.	1113.	247.	0.	49.	0.	0.	730.	14.	0.	0.
150	12060.	1267.	362.	1076.	255.	0.	60.	0.	0.	1046.	13.	0.	0.
151	14021.	1024.	1112.	1076.	291.	0.	99.	0.	0.	1242.	15.	0.	0.
152	16619.	1110.	388.	1066.	251.	0.	84.	0.	0.	1426.	16.	0.	0.
153	25134.	1480.	457.	1071.	246.	0.	142.	0.	0.	1289.	16.	0.	0.
154	32082.	1907.	652.	1081.	227.	0.	139.	0.	0.	22893.	6.	0.	0.
155	40457.	2741.	893.	1006.	206.	0.	227.	0.	0.	3772.	15.	0.	0.
156	42776.	53887.	924.	1021.	200.	0.	200.	0.	0.	4038.	17.	0.	0.
157	29469.	7724.	989.	1028.	143.	0.	153.	0.	0.	3554.	28.	0.	0.
158	21085.	17325.	1255.	1133.	112.	0.	96.	0.	0.	3554.	28.	0.	0.
159	21085.	20469.	1655.	1066.	67.	0.	67.	0.	0.	2094.	47.	0.	0.
160	12376.	20667.	2016.	1232.	40.	0.	40.	0.	0.	1237.	47.	0.	0.
161	11798.	18887.	3279.	1415.	38.	0.	38.	0.	0.	891.	59.	0.	0.
162	9373.	5575.	4943.	1406.	24.	0.	24.	0.	0.	601.	59.	0.	0.
163	6851.	5851.	7778.	1426.	13.	0.	13.	0.	0.	580.	55.	0.	0.
164	5243.	3641.	9256.	1575.	12.	0.	10.	0.	0.	386.	64.	0.	0.
165	3599.	2223.	9253.	1889.	9.	0.	8.	0.	0.	239.	69.	0.	0.
166	2281.	1663.	9723.	2444.	7.	0.	6.	0.	0.	78.	74.	0.	0.
167	1506.	1030.	7770.	3307.	58.	0.	58.	0.	0.	83.	76.	0.	0.
168	1063.	7114.	3175.	4746.	10.	0.	10.	0.	0.	59.	77.	0.	0.
169	970.	381.	1886.	9050.	6.	0.	6.	0.	0.	91.	77.	0.	0.
170	692.	271.	1230.	10068.	40.	0.	40.	0.	0.	38.	72.	0.	0.
171	449.	207.	809.	10421.	22.	0.	22.	0.	0.	30.	71.	0.	0.
172	186.	189.	1044.	10444.	26.	0.	26.	0.	0.	20.	77.	0.	0.
173	109.	146.	567.	10228.	1.	0.	1.	0.	0.	10.	77.	0.	0.
174	66.	130.	359.	9847.	1.	0.	1.	0.	0.	6.	66.	0.	0.
175	41.	85.	179.	9364.	1.	0.	1.	0.	0.	4.	65.	0.	0.
176	27.	47.	97.	9245.	2.	0.	2.	0.	0.	1.	64.	0.	0.
177	16.	23.	29.	8726.	2.	0.	2.	0.	0.	1.	64.	0.	0.
178	7.	18.	0.	4044.	4.	0.	4.	0.	0.	0.	83.	0.	0.
179	3.	13.	0.	7133.	5.	0.	5.	0.	0.	0.	73.	0.	0.
180	0.	0.	0.	9819.	5.	0.	5.	0.	0.	0.	72.	0.	0.
181	1.	4.	0.	5638.	8.	0.	8.	0.	0.	0.	382.	0.	0.
182	0.	0.	0.	2451.	11.	0.	11.	0.	0.	0.	718.	0.	0.
183	0.	0.	0.	1471.	15.	0.	15.	0.	0.	0.	553.	0.	0.
184	0.	0.	0.	914.	15.	0.	15.	0.	0.	0.	920.	0.	0.
185	0.	0.	0.	8836.	22.	0.	22.	0.	0.	0.	2123.	0.	0.
186	0.	0.	0.	559.	24.	0.	24.	0.	0.	0.	2034.	0.	0.
187	0.	0.	0.	361.	24.	0.	24.	0.	0.	0.	1654.	0.	0.
188	0.	0.	0.	350.	32.	0.	32.	0.	0.	0.	1133.	0.	0.
189	0.	0.	0.	113.	32.	0.	32.	0.	0.	0.	833.	0.	0.
190	0.	0.	0.	55.	45.	0.	45.	0.	0.	0.	630.	0.	0.
191	0.	0.	0.	19.	27.	0.	27.	0.	0.	0.	429.	0.	0.
192	0.	0.	0.	0.	2.	0.	2.	0.	0.	0.	410.	0.	0.
193	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	317.	0.	0.
194	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	202.	0.	0.
195	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	95.	0.	0.
196	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	56.	0.	0.
197	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	32.	0.	0.
198	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6.	0.	0.
199	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	20.	0.	0.
200	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
201	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
202	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
203	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
204	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
205	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.



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